PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-196925
(43)Date of publication of application : 06.08.1993

(51)Int.Cl. G02F 1/1333
G02F 1/13

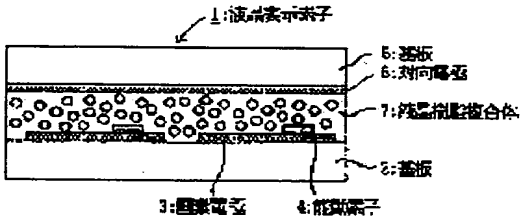
(21)Application number : 04-298017
(22)Date of filing : 09.10.1992

(71)Applicant : ASAHI GLASS CO LTD
(72)Inventor : HIRAI YOSHINORI
NIIYAMA SATOSHI
KUMAI YUTAKA
KORISHIMA TOMONORI

(30)Priority
Priority number : 03112562 Priority date : 17.04.1991 Priority country : JP

(54) PROJECTION TYPE LIQUID CRYSTAL DISPLAY DEVICE

(57)Abstract:
PURPOSE: To greatly improve the transmittance of light at the time of transmission without requiring a polarizing plate and to enable gradation display of beautiful halftone by using a liquid crystal optical element formed by clamping a liquid crystal resin composite capable of electrically controlling a scattering state and a transmission state as a liquid crystal material to be clamped between a pair of substrates with electrodes of the liquid crystal display element.
CONSTITUTION: A liquid crystal is dispersed and held in a resin matrix between a pair of the substrates 2 and 5 with the electrodes so that the refractive index of this resin matrix coincides nearly with the refractive index of the liquid crystal to be used in either of the time of impressing the voltage or the time of not impressing the voltage and the two refractive indices do not coincide at the other time. Further, the liquid crystal optical element 1 is constituted by clamping the liquid crystal resin composite with which the modulus of elasticity of the resin material constituting the resin matrix is $\leq 3 \times 10^7$N/m2 at 20° C and $\geq 1 \times 10^3$N/m2 at 40° C. As a result, the light source for projection and the optical system for (x) projection are combined.



LEGAL STATUS

Date of request for examination]

Date of sending the examiner's decision of rejection]

Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

Date of final disposal for application]

Patent number]

Date of registration]

Number of appeal against examiner's decision of rejection]

Date of requesting appeal against examiner's decision of rejection]

Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] Between the substrates with an electrode of a pair, distributed maintenance of the liquid crystal is carried out into a resin matrix, and are mostly in agreement with the refractive index of the liquid crystal which the refractive index of the resin matrix uses in either at the time of electrical-potential-difference impression or un-impressing. The elastic modulus of the resin ingredient which it is made not in agreement [both refractive indexes] on the other hand, and constitutes a resin matrix further is at 20 degrees C. 3x107 N/m2 Following, At 40 degrees C 1x103 N/m2 Projection mold liquid crystal display characterized by combining the liquid crystal optical element which comes to pinch the liquid crystal resin complex which it is above, the light source for projection, and an incident light study system.
[Claim 2] The projection mold liquid crystal display with which temperature which becomes the maximum of the loss modulus of the resin ingredient which constitutes the resin matrix of a liquid crystal optical element in the projection mold liquid crystal display of claim 1 is characterized by using the liquid crystal optical element which is 0 or less degree C.
[Claim 3] The projection mold liquid crystal display with which the resin ingredient which constitutes the resin matrix of a liquid crystal optical element is characterized by using the liquid crystal optical element to which photo-curing of the photoresist vinyl system compound is carried out in the projection mold liquid crystal display of claims 1 or 2.
[Claim 4] In claim 1 or the projection mold liquid crystal display of 2 or 3 as a substrate with an electrode of the pair of a liquid crystal optical element As liquid crystal resin complex pinched in the meantime, using the active-matrix substrate which prepared the active element for every pixel electrode, and the counterelectrode substrate which prepared the counterelectrode Distributed maintenance of the nematic liquid crystal which has a forward dielectric anisotropy is carried out into a resin matrix. The projection mold liquid crystal display characterized by performing the display including halftone using the liquid crystal optical element which comes to pinch the liquid crystal resin complex it was made mostly in agreement [complex] with the Tsunemitsu refractive index (n0) of the liquid crystal which the refractive index of the resin matrix uses.

Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the projection mold liquid crystal display using the liquid crystal optical element by which distributed maintenance of the liquid crystal was carried out into the resin matrix between the substrates with an electrode of a pair.
[0002]
[Description of the Prior Art] The liquid crystal display is widely used for the personal word processor, the hand held computer, Pocket TV, etc. in recent years taking advantage of the features, such as the low power and a low-battery drive. It is observed especially and the liquid crystal display component which has arranged the active element for every pixel electrode is developed briskly.
[0003] in the DSM mold, although the liquid crystal display component which used the liquid crystal of a DSM (dynamic scattering) mold was also proposed, since such a liquid crystal display component has the high current value which flows the inside of liquid crystal, there is a fault that the consumed electric current is large, what uses TN (the twist -- nematic) mold liquid crystal in current has become in use, and it has appeared in the commercial scene as a pocket TV at the beginning. In the TN liquid crystal, since the leakage current is very small and there is little power consumption, it is suitable for the application which uses a cell as a power source.
[0004]
[Problem(s) to be Solved by the Invention] When using the liquid crystal display component which has arranged the active element in DS mode, the own leakage current of liquid crystal is large. For this reason, big storage capacitance had to be prepared in each pixel and juxtaposition, and it had the trouble that the power consumption of the liquid crystal display component itself became large.
[0005] In TN mode, since the own leakage current of liquid crystal is very small, it is not necessary to add big storage capacitance, and power consumption of the liquid crystal display component itself is made small. However, in TN mode, since two polarizing plates are needed, it has the trouble that the permeability of light is small. When performing color display especially using a color filter, it can use several% of the light which carries out incidence, and the strong light source will be needed, therefore power consumption will be made to increase as a result.
[0006] Moreover, in case an image is projected, the very strong light source is needed, and it has the trouble of the effect on the liquid crystal display component by that high contrast is hard to be acquired on a projection screen, and generation of heat of the light source.
[0007] Then, the liquid crystal resin complex which carried out distributed maintenance of the nematic liquid crystal into the resin matrix is used that the technical problem in TN mode should be solved, and the mode which can be driven by the low battery using the dispersion-transparency property not more than 10V is proposed.
[0008] However, in the conventional liquid crystal resin complex, the hysteresis existed in the electrical-potential-difference-permeability property, i.e., it has the technical problem that permeability differs at the time of a pressure up and pressure lowering, therefore there was a trouble that the printing phenomenon in which the information on a front screen will remain over several seconds or more at the time of change of the display screen might arise.
[0009]
[Means for Solving the Problem] This invention has high brightness and a high contrast ratio, can perform a halftone display finely, and offers the projection mold liquid crystal display using the liquid crystal optical element which reduced the printing phenomenon based on the hysteresis of liquid crystal resin complex.
[0010] Namely, distributed maintenance of the liquid crystal is carried out into a resin matrix between the substrates with an electrode of a pair. Are mostly in agreement with the refractive index of the liquid crystal which the refractive index of the resin matrix uses in either at the time of electrical-potential-difference impression or un-impressing. The elastic modulus of the resin ingredient which it is made not in agreement both refractive indexes] on the other hand, and constitutes a resin matrix further is at 20 degrees C. 3x107

N/m2 Following, At 40 degrees C 1x103 N/m2 The liquid crystal optical element which comes to pinch the liquid crystal resin complex which it is above, The projection mold liquid crystal display characterized by combining the light source for projection, and an incident light study system, And the temperature which becomes the maximum of the loss modulus of the resin ingredient which constitutes the resin matrix of a liquid crystal optical element The projection mold liquid crystal display characterized by using the liquid crystal optical element which is 0 degree C or less, and as the projection mold liquid crystal display with which the resin ingredient which constitutes the resin matrix of a liquid crystal optical element is characterized by using the liquid crystal optical element to which photo-curing of the photoresist vinyl system compound is carried out, and a substrate with an electrode of the pair of a liquid crystal optical element As liquid crystal resin complex pinched in the meantime, using the active-matrix substrate which prepared the active element for every pixel electrode, and the counterelectrode substrate which prepared the counterelectrode Distributed maintenance of the nematic liquid crystal which has a forward dielectric anisotropy is carried out into a resin matrix. The projection mold liquid crystal display characterized by performing the display including halftone using the liquid crystal optical element which comes to pinch the liquid crystal resin complex it was made mostly in agreement [complex] with the Tsunemitsu refractive index (n0) of the liquid crystal which the refractive index of the resin matrix uses is offered.

[0011] According to this invention, by taking the above-mentioned configuration, the printing phenomenon based on a hysteresis is reduced, and it has a high contrast ratio, and the projection mold liquid crystal display which can be driven by the low battery can be obtained.

[0012] In this invention, between the substrates with an electrode of a pair, distributed maintenance of the liquid crystal is carried out into a resin matrix, and the liquid crystal resin complex both whose refractive indexes do not correspond on the other hand is pinched and used almost in accordance with the refractive index of the liquid crystal which the refractive index of the resin matrix uses in either at the time of electrical-potential-difference impression or un-impressing.

[0013] Distributed maintenance of the nematic liquid crystal which has a forward dielectric anisotropy especially is carried out into a resin matrix, and the liquid crystal resin complex it was made mostly in agreement [complex] with the Tsunemitsu refractive index (n0) of the liquid crystal which the refractive index of the resin matrix uses is used. And it pinches between the active-matrix substrate which prepared the active element for liquid crystal resin complex for every pixel electrode, and the counterelectrode substrate which prepared the counterelectrode.

[0014] This substrate with an electrode means that by which the electrode was formed on substrates, such as glass, plastics, and a ceramic. Usually, let this electrode be the transparent electrode of ITO (In2O3-SnO2) or SnO2 grade. Furthermore, metal electrodes, such as chromium and aluminum, may be used together if needed. Moreover, when used with a reflective mold, it may consider as a reflector. Moreover, as a substrate of this pair, there is also combination of a active-matrix substrate and a counterelectrode substrate.

[0015] This active-matrix substrate is a substrate with which an electrode and active elements, such as a thin film transistor (TFT), a thin-film diode, and a metallic insulator metal nonlinear resistance component (MIM), were formed on the substrate. One piece thru/or two or more active elements are connected to each of this pixel electrode at each. Moreover, an electrode is formed on a substrate, and this counterelectrode substrate can be displayed combining a active-matrix substrate substrate, and is made.

[0016] Liquid crystal resin complex is pinched between the electrode substrates of this pair. As for this liquid crystal resin complex, the refractive index of the liquid crystal in liquid crystal resin complex changes with the impression conditions of an electrical potential difference. When the refractive index of the resin matrix is mostly in agreement with the refractive index of liquid crystal, light penetrates, and light is scattered about when not in agreement. Since the polarizing plate is not used for this, a bright display is obtained easily.

[0017] Under the present circumstances, by making it mostly in agreement with the Tsunemitsu refractive index (n0) of the liquid crystal which the refractive index of that resin matrix uses, when an electrical potential difference is impressed, light is penetrated, and when not impressing an electrical potential difference, light will be scattered about. Since a liquid crystal molecule arranges in parallel with the direction of electric field at the time of electrical-potential-difference impression, it is easy to control a refractive index and permeability with this type of component high at the time of transparency is obtained.

[0018] The liquid crystal optical element used for the projection mold liquid crystal display of this invention can also be used as a liquid crystal display component in itself. Moreover, it can also use as a modulated light aperture or an optical shutter. As this liquid crystal display component, it can use by both the direct viewing type display device and the projection mold display device. What is necessary is just to constitute a display combining back light, a lens, prism, a mirror, a diffusion plate, a light absorption object, a color filter, etc. according to a display property to acquire, when using as a direct viewing type display device.

[019] Let the projection mold liquid crystal display of this invention be a projection mold liquid crystal display combining a liquid crystal display component, the light source for projection, an incident light study system, etc. The light source for projection and an incident light study system can use incident light study systems, such as

the well-known light source for projection, and a lens, from the former, arrange the above-mentioned liquid crystal display component between the light source for projection, and a projector lens, and should just usually use it.

[0020] In the liquid crystal optical element used for this invention, the liquid crystal resin complex of a transparency-dispersion mold is pinched between the substrates with an electrode of a pair.

[0021] Specifically by this invention, the liquid crystal resin complex which consists of a resin matrix by which a large number formation of the hole fine as a liquid crystal optical element was carried out, and liquid crystal with which the part of the hole was filled up is used. This liquid crystal resin complex is pinched between the substrates with an electrode of a pair. The refractive index of the liquid crystal changes with the impression conditions of an electrical potential difference inter-electrode [the], and the relation between the refractive index of a resin matrix and the refractive index of liquid crystal changes. When these both refractive index is in agreement, it will be in a transparency condition, and when refractive indexes differ, a liquid crystal display component which will be in a dispersion condition can be used.

[0022] The liquid crystal resin complex which consists of a resin matrix by which a large number formation of this fine hole was carried out, and liquid crystal with which the part of that hole was filled up is the structure by which liquid crystal was confined in a liquid bubble like a microcapsule. However, each microcapsule does not need to be independent completely and the liquid bubble of each liquid crystal may be open for free passage through a slit like a porous body.

[0023] The liquid crystal resin complex of a liquid crystal display component used for the projection mold liquid crystal display of this invention is manufactured as follows. Liquid crystal and the hardenability compound which constitutes a resin matrix are mixed, and it is made the shape of the shape of a solution, and a latex. Subsequently, what is necessary is for photo-curing, heat curing, hardening by solvent removal, reaction hardening, etc. to carry out this, to separate a resin matrix, and just to take the condition that liquid crystal distributed in the resin matrix.

[0024] In this invention, that elastic modulus is at 20 degrees C as this resin ingredient. 3x107 N/m2 At the following and 40 degrees C 1x103 N/m2 The resin ingredient which it is above is used. It is desirable to make it go into the above-mentioned range in many parts of a service temperature region especially. Thereby, the printing phenomenon by the hysteresis can be reduced. Since the hardenability compound furthermore used can be hardened within a sealing system by making it photo-curing or a heat-curing type, it is desirable. By using a photo-curing type hardenability compound especially, it cannot be influenced by heat, can be made to harden for a short time, and is desirable.

[0025] A cel is formed using a sealant like the conventional usual nematic liquid crystal as a concrete process, and non-hardened mixture [compound / liquid crystal and / hardenability] is poured in from an inlet, and it can treat whether an inlet is closed and an optical exposure is carried out the back, and can also be made to harden.

[0026] Moreover, on the substrate which prepared the transparent electrode in the case of the liquid crystal optical element used for this invention, not using a sealant, non-hardened mixture [compound / liquid crystal and / hardenability] can be supplied, and the substrate with an electrode of another side can also be stiffened by optical exposure etc. in piles after that.

[0027] Of course, after that, a sealant may be applied on the outskirts and the seal of the circumference may be carried out. According to this process, in order for what is necessary to be just to only supply a roll coat, a spin coat, printing, spreading according non-hardened mixture [compound / liquid crystal and / hardenability] to a dispenser, etc., an impregnation process is simple and productivity is very good.

[0028] Moreover, into non-hardened mixture [compounds / these / liquid crystal and hardenability compounds], spacers, such as a ceramic particle for substrate gap control, a plastics particle, and a glass fiber, a pigment, coloring matter, a viscosity controlling agent, and the other additives that do not have a bad influence on the engine performance of this invention may be added.

[0029] Since that part can always be changed into a light transmission condition by stiffening only a specific part in the case of this hardening process where a sufficiently high electrical potential difference is impressed, when the thing which wants to indicate by fixed is in the component which will be in a transparency condition at the time of electrical-potential-difference impression, such a usual state transparency part may be formed. On the contrary, when the component which will be in a dispersion condition is used at the time of electrical-potential-difference impression, a usual state dispersion part can be formed similarly.

[0030] In addition, the permeability in the transparency condition of the liquid crystal optical element which used this liquid crystal resin complex is so good that it is high, and, as for the Hayes value in a dispersion condition, it is desirable that it is 80% or more.

[0031] It is desirable to make it in agreement with the Tsunemitsu refractive index (no) of the liquid crystal which the refractive index of a resin matrix (hardening back) uses in the condition of impressing the electrical potential difference, by this invention. By this, when the refractive index of a resin matrix and the refractive index of liquid crystal are in agreement, light penetrates, and light will be scattered about when not in agreement (nebula). The dispersion nature of this component is higher than the case of the liquid crystal display component

in the conventional DS mode, and the display of a high contrast ratio is obtained.
.0032] The biggest purpose of this invention offers a projection mold liquid crystal display using the liquid crystal optical element which reduces the printing phenomenon based on the hysteresis of liquid crystal resin complex, and can be driven by the low battery. This liquid crystal optical element can discover a high function rather than a high density display by combining with an active element. Of course, in addition to this, the function can be effectively demonstrated also in the applications (an aperture, a shutter, a display, space modulator, etc.) of an and also [it is the need for halftone].
.0033] In the conventional liquid crystal resin complex, it had become a trouble at the time of a hysteresis existing in an electrical-potential-difference-permeability property and it indicating by gradation. A hysteresis is the phenomenon in which permeability differs in the process in which an electrical potential difference is gone up, and the process in which an electrical potential difference is dropped. When the hysteresis existed, in case it s a gradation display, the information on a front screen remains, namely, the phenomenon in which an image was burned arose, and this was reducing image quality.
.0034] Liquid crystal resin complex depends one of the causes by which a hysteresis exists in liquid crystal resin complex on the structure where distributed maintenance of the liquid crystal is carried out into resin. That is, it s thought that a hysteresis exists by the interaction of the liquid crystal which dissociate and exist in resin. The size of this hysteresis is determined by the electric energy by the electric field impressed from the elastic energy conserved into the liquid crystal held in resin, and outside, and the interaction energy of the liquid crystal which dissociate and exist in resin. Therefore, a hysteresis can be reduced by optimizing this energy balance, and also in case it is a gradation display, the outstanding display without printing can be obtained.
.0035] The purpose of this invention is obtaining the liquid crystal display using the liquid crystal optical element which has a high contrast ratio, high brightness, and the outstanding responsibility, and reduced the hysteresis. Furthermore, it is obtaining the liquid crystal display using the liquid crystal optical element which can be driven n the conventional active element and conventional drive circuit for TN.
0036] The important factors which determine the above-mentioned energy balance are anisotropy deltaepsilon, he elastic coefficient of liquid crystal, the elastic modulus of a resin matrix, a dielectric constant, etc. at the nean particle diameter R of the liquid crystal by which distributed maintenance is carried out into resin, the configuration of a liquid crystal particle, and the dielectric constant list of liquid crystal. When optimizing for the above-mentioned purpose, it is important to optimize in consideration of this energy balance being closely connected also with the electrical-potential-difference-permeability property of a component and the dynamic rait (responsibility) of liquid crystal.
0037] In the above-mentioned energy balance, the elastic property of a resin matrix plays an important role in espect of the stability of a liquid crystal array. In case liquid crystal carries out a rearrangement by impression f electric field when a matrix has an elastic modulus big enough as compared with the elastic coefficient which he liquid crystal to be used has (when a matrix is harder enough than liquid crystal), deformation of a matrix is ardly produced. For this reason, a liquid crystal array is determined by the electric and elastic energy of the quid crystal itself with the liquid crystal particle shape at the time of non-electric field.
0038] On the other hand, when producing deformation of the matrix itself in the case of the liquid crystal earrangement by electric-field impression, a liquid crystal array is determined by the electric and elastic energy f the liquid crystal itself, and the elastic energy of a matrix. Generally, the elastic coefficient of liquid crystal is bout 10-11N, and is the average diameter of a liquid crystal particle. They are about 1-3 micrometers. For this eason, the elastics modulus of a matrix are 107 N/m2. When smaller than extent or it, deformation of a matrix omes to contribute in energy. In such a soft matrix, the rearrangement of liquid crystal happens with eformation of a matrix according to the impressed electric field.
0039] It is mentioned that array change of the liquid crystal in each liquid crystal particle produces a big change f the dielectric constant of the location as one factor of a hysteresis. This dielectric constant change produces hange of electric field to the location of other liquid crystal particles. For this reason, the phenomenon in which ne liquid crystal array in the liquid crystal particle distributed in a system is not uniquely decided to the applied oltage which exists from the exterior arises.
0040] It deforms [at the time of change of the array of liquid crystal / the configuration of a matrix] from this ewpoint namely, is desirable that it is soft. The interface of liquid crystal and a matrix will be fixed in the matrix ard enough. Thereby, in a certain electric field, a rapid change (Fredericks transition) of an array arises with the se of impression electric field. For this reason, this becomes the factor which produces a lifting and a ysteresis about a big dielectric constant change.
0041] In a matrix soft on the other hand enough, it is hard to produce the abrupt change of a liquid crystal ray, the array of liquid crystal is stabilized to the electric field currently impressed according to deformation of matrix, and a hysteresis is reduced. Moreover, in a matrix soft enough, array change of liquid crystal and eformation of a matrix may take place by adding small electric energy from the outside. For this reason, it also as the advantage of being easy to attain reduction of a hysteresis, and a drive by the low battery to incidence.

[0042] As an elastic modulus of the resin ingredient which constitutes a matrix from having stated above, it is at 20 degrees C. 3x107Ns/m2 It is the following. Especially, it is 1.5x107 N/m2. The following is desirable.
[0043] When the elastic modulus of a matrix is too low, a problem is produced in the structural stability of a matrix, or ON of electric field, and when off, the problem that sufficient force of restoring a liquid crystal array does not work arises. For this reason, the elastic modulus of a matrix has the minimum and is at 40 degrees C. 1x103 N/m2 It considers as the above. When used with usual room temperature extent, they are 3x107 N/m2 - 1x103 N/m2 in a 20-40-degree C temperature region. It is carried out. Especially, two or more [5x103Ns //m] are more desirable.
[0044] Moreover, in order to attain reduction of a hysteresis in a practical temperature requirement, as for the glass transition temperature of a matrix, it is desirable that it is fully lower than a service temperature region. It is desirable that the temperature used as the maximum of the loss modulus which specifically originated in the glass transition of the principal chain of the resin ingredient which constitutes the resin matrix of liquid crystal resin complex is lower than a service temperature region. Generally, the temperature used as the maximum of a loss modulus It is desirable that it is 0 degree C or less.
[0045] In addition, a resin ingredient here points to the resin ingredient itself which does not contain liquid crystal. Moreover, 11Hz and a dynamic strain an elastic modulus 1% or less of sinusoidal amplitude is applied, and it is a programming rate. It is a part for 3-degree-C/and defines by the dynamic storage modulus obtained by viscoelasticity measurement at the time of hauling.
[0046] Even if the resin part of a resin matrix consists of only resin, it may consist of resin swollen with liquid crystal. When having swollen with liquid crystal, generally, the glass transition temperature as liquid crystal resin complex is shifted to the degree region of low temperature rather than the case of a resin simple substance, and an absolute elastic modulus also falls. Therefore, control of a finer matrix elastic modulus is possible by using the swelling by liquid crystal further, using the desirable resin ingredient of the above-mentioned range as a matrix component. the amount of liquid crystal swollen in a matrix changes with the liquid crystal ingredients and resin ingredients to be used, and a resin ingredient is received -- the 0 - dozens wt(s)% amount of swelling can be taken.
[0047] Therefore, as an elastic modulus of the matrix swollen with liquid crystal, it is specified in the range lower than the elastic modulus only in the case of the above-mentioned resin, and, generally is at 20 degrees C. 8x106 N/m2 The following is desirable and it is 4x106 N/m2 especially. The following is more desirable. moreover -- as a minimum -- 40 degrees C -- 103 N/m2 it considers as the above -- 2x103 N/m2 The above is more desirable. Moreover, as for the temperature used as the maximum of the loss modulus of a matrix swollen with the liquid crystal of liquid crystal resin complex, it is desirable that it is -5 degrees C or less.
[0048] On the other hand, it is possible to reduce the glass transition temperature, and such structure may be prepared in some resin used here because resin contains -(Si(CH3)2-O-) n- (polysiloxane structure), -C6H12-, etc. (hexamethylene structure).
[0049] furthermore -- as the number like the hard spot in 1 molecule Semantics of [although the thing of 1-10 is chosen] the stability of structure Resin which constitutes a matrix for the thing of 2 - 6 organic functions more than 5wt% -- using is desirable. Furthermore, in order to control the liquid crystal particle diameter of liquid crystal resin complex, particle size distribution, grain density, etc., it is desirable to mix and use two or more sorts of hardenability compounds with which molecular weight differs, and a certain thing has the desirable ratio of the greatest thing of those molecular weight, and the minimum thing 1.5 or more times.
[0050] As the concrete manufacture approach, the hardenability compound which fills the above-mentioned physical-properties range after hardening is dissolved in a liquid crystal ingredient and homogeneity, and the technique in which the phase separation structure of liquid crystal and a resin matrix is made to form by hardening of a hardenability compound is mentioned. Under the present circumstances, it is possible by mixing other hardenability compounds, reaction initiators, etc. suitably to control the balance of the compatibility of the system before and behind hardening and the property of a matrix. Especially the thing for which phase separation structure is formed by optical exposure using a photoresist vinyl system compound is desirable from both sides of structure control and productivity. In this case, acrylic resin and the thing which has an acrylic radical as a functional group especially are desirable.
[0051] In order to reduce the hysteresis accompanying the liquid crystal particle distributing in a resin matrix, it is also important for the dielectric constant of liquid crystal, and its anisotropy deltaepsilon list to balance the dielectric constant of a resin matrix. Moreover, the configuration of the particle of liquid crystal is also an important factor. The effectiveness of this invention can be strengthened by balancing the factor of these others. as dielectric anisotropy deltaepsilon of the liquid crystal to be used -- 5 < -- deltaepsilon < -- It is the desirable range to fill the relation of 13.
[0052] It is an amount related to [in deltaepsilon] both driver voltage to a hysteresis list, and an upper limit is decided from the magnitude of a hysteresis and a minimum is decided from driver voltage. This condition looks disadvantageous apparently from the common sense of the conventional TN liquid crystal display device that driver voltage becomes low, so that deltaepsilon is large. However, in the system which such a liquid crystal

particle distributed, the concept of the conventional TN liquid crystal display device that driver voltage is in inverse proportion to the square root of deltaepsilon is not materialized.
[0053] This is because electrical-potential-difference allocation into a liquid crystal part and a matrix part changes with arrays of liquid crystal. Generally, at such a system, for the not much big effect to driver voltage, it is not shown but deltaepsilon is deltaepsilon. In the bigger range than 5, driver voltage does not necessarily become very high by making deltaepsilon small.
[0054] moreover, dielectric constant epsilonm [as opposed to the electrical potential difference low enough below the threshold electrical potential difference of liquid crystal resin complex in reduction of a hysteresis] dielectric constant anisotropy deltaepsilon of the liquid crystal to be used -- deltaepsilon < -- It is desirable to have the relation between 1.45 and epsilonm.
[0055] If deltaepsilon is larger than this range, a motion of the liquid crystal in one liquid crystal particle will serve as a big dielectric constant change in that particle. Consequently, big field changes are produced around the particle. For this reason, the electric interaction between the liquid crystal particles which are the factor which causes a hysteresis will become large. epsilonm It is an amount also related to the dielectric constant of a resin matrix, and if the dielectric constant of a resin matrix increases, dielectric constant epsilonm of the whole liquid crystal resin complex will increase, and the range of deltaepsilon which can be taken will also spread.
[0056] Although a nematic liquid crystal or a smectic liquid crystal can be used for the liquid crystal used by this invention, its use of a nematic liquid crystal is desirable. Moreover, cholesteric liquid crystal may be added to the part, or dichroic coloring matter and mere coloring matter may be added. Furthermore, spacers, such as a viscosity controlling agent, an alumina particle, and a glass fiber, other additives, etc. may be added to this.
[0057] Refractive-index anisotropy deltan of liquid crystal It is the important factor which determines an electro-optics property. In order to take the large dispersion nature in the condition of not applying electric field, it is desirable that the refractive-index anisotropy of the liquid crystal to be used is 0.18 or more, and 0.20 or more are more desirable especially.
[0058] When making it in agreement [the refractive index of liquid crystal and a resin matrix] in this invention at the time of electrical-potential-difference impression, since the permeability at the time of transparency becomes high, it is desirable. For this reason, it is desirable to carry out as [be / use the nematic liquid crystal of a forward dielectric anisotropy, and / the Tsunemitsu refractive index (no) of liquid crystal / mostly in agreement with the refractive index np of a resin matrix]. At this time, high transparency is acquired at the time of electrical-potential-difference impression. It is desirable to specifically fill the relation of no-0.03<np<no +0.05.

[0059] As for the liquid crystal by which distributed maintenance is carried out into a resin matrix, it is desirable that they are the independent particle or the particle which the part opened for free passage. Since it is compatible in the high permeability at the time of driving by high scattering power and a high low battery, this is effective. Dispersion is caused by existence of the interface of liquid crystal and resin. For this reason, dispersion nature improves, so that the area of this interface is large.
[0060] It is important to make [many] independently resin and the separated amount of liquid crystal, namely, to make [many] liquid crystal grain density with a certain optimal mean particle diameter, in order to increase the area of this interface. However, if resin and the separated amount of liquid crystal are increased, it will come to take the structure which each liquid crystal particle came to open for free passage someday, and all liquid crystal opened for free passage further. Since this leads to loss of resin and the separated liquid crystal interface, it leads to the fall of scattering power.
[0061] Moreover, in order to make driver voltage low, it is important that each liquid crystal held in resin has almost equal drive electric field. For that, it is more advantageous for liquid crystal to have a clear interface between resin, loss of an interface leads to distribution of drive electric field, and there is an inclination which produces the fall of a contrast ratio and the rise of driver voltage. For this reason, as for the liquid crystal by which distributed maintenance is carried out into resin, it is desirable that it is the particle which the independent particle or part which exists in high density opened for free passage.
[0062] The above-mentioned explanation explains the case of an independent liquid crystal optical element. When making each liquid crystal display component divide and penetrate the light of RGB3 color using three liquid crystal display components so that it may use for a projection mold liquid crystal display etc., it is desirable to adjust the refractive index of the particle size of liquid crystal, a substrate gap, and liquid crystal etc. for every color, and to arrange the property for every color.
[0063] Moreover, in order to raise the dispersion nature at the time of non-electric field, it is effective to make the volume fraction phi of the liquid crystal which can operate liquid crystal resin complex increase. phi> 20% is desirable, and for having higher dispersion nature, phi> 35% is desirable, and it is phi> 45% of specifically still more desirable. If phi becomes not much large, since the structural stability of liquid crystal resin complex will worsen on the other hand, phi< 70% is desirable.
[0064] As for the liquid crystal optical element in this invention, it is desirable to make it mostly in agreement with the Tsunemitsu refractive index (n0) of the liquid crystal which the refractive index of the resin matrix uses.

In this case, when the electrical potential difference is not impressed, a dispersion condition (that is, nebula condition) is compulsorily indicated to be the liquid crystal which has not been arranged perpendicularly to a substrate by the difference in the refractive index of a resin matrix. For this reason, as for the part without an electrode, light is scattered about.

[0065] Since light does not reach a projection screen even if no parts other than a picture element part part prepare a light-shielding film, since light is scattered about in using this liquid crystal optical element as a projection mold display, it looks black. By this, in order to prevent the leakage of the light from parts other than a pixel electrode, it is not necessary to shade any parts other than a pixel electrode by a light-shielding film etc. For this reason, it also has the advantage that the formation process of a light-shielding film becomes unnecessary.

[0066] Electric field are impressed to the pixel of the request to this. In a part for the picture element part to which this electric field were impressed, liquid crystal arranges and the Tsunemitsu refractive index (no) of liquid crystal and the refractive index (np) of a resin matrix are in agreement. This shows a transparency condition, and by the pixel of the request concerned, light will penetrate and it is brightly displayed on a projection screen.

[0067] That part can always be made into a light transmission condition by stiffening only a specific part for this component, in the case of this hardening process, where an electrical potential difference high enough is impressed. When there is a thing which wants to indicate by fixed, such a usual state transparency part may be formed.

[0068] Moreover, the liquid crystal display component in this invention can perform color display by preparing a color filter. 3 ******** of this color filter are good for one liquid crystal display component, and 1 ******** may also combine three of these with one liquid crystal display component. This color filter may be prepared in the electrode surface side of a substrate, and may be prepared outside.

[0069] Moreover, it may be made to perform color display by mixing the color, the pigment, etc. into liquid crystal resin complex.

[0070] Drawing 1 is the mimetic diagram of the projection mold liquid crystal display using the liquid crystal display component shown in drawing 2 . In drawing 1 , the incident light study system in which the light source for projection and 21 contain a liquid crystal display component in, and, as for 13, 11 contains a lens, an aperture, etc., and 14 show the projection screen to project. In addition, the incident light study system contains the aperture which is the plate with which the hole opened, the spot 15, the condenser lens 16, and the projector lens 17 in this example.

[0071] Drawing 2 is a sectional view in one example of the liquid crystal display component in this invention, and is a sectional view at the time of using a active-matrix substrate. it sets to drawing 2 -- the glass for [1] active-matrix substrates in a liquid crystal display component and 2 -- Substrates, such as plastics, and 3 ITO (In2O3-SnO2), the pixel electrode of SnO2 grade, substrates, such as glass for [4 /] counterelectrode substrates in active elements, such as a transistor, diode, and a nonlinear resistance component, and 5, and plastics, and 6 -- ITO and SnO2 etc. -- a counterelectrode and 7 show the liquid crystal resin complex pinched among both substrates.

[0072] When using 3 terminal components, such as TFT (thin film transistor), as an active element, a counterelectrode substrate should just prepare a solid electrode common to all pixels. When using 2 terminal components, such as an MIM component and a PIN diode, a counterelectrode substrate is carried out in stripe-like patterning.

[0073] Moreover, as an active element, in using TFT, as a semiconductor material, silicon is suitable and it obtains. Since especially polycrystalline silicon does not have photosensitivity like amorphous silicon, whether it does not shade the light from the light source by the light-shielding film or it is not a strict light-shielding film, it cannot malfunction easily, and is desirable. When using this polycrystalline silicon as a projection mold liquid crystal display like this invention, the strong light source for projection can be used and a bright display is obtained.

[0074] Moreover, in order to inhibit the leakage of the light from between pixels in the case of the conventional TN liquid crystal optical element, a light-shielding film is formed between pixels in many cases. In this case, a coincidence light-shielding film can be formed also in an active element part in passing. For this reason, forming a light-shielding film in an active element part seldom affects the whole process. That is, even if it will not form a light-shielding film in an active element part, using polycrystalline silicon as an active element, a process cannot be reduced if it is necessary to form a light-shielding film between pixels.

[0075] On the other hand, it is desirable to use the liquid crystal resin complex it was made mostly in agreement complex] with the Tsunemitsu refractive index (no) of the liquid crystal which the refractive index of a resin matrix uses like the above-mentioned in this invention. Thereby, on the projection screen on which it was projected by scattering about light, since it becomes black, it is not necessary to form a light-shielding film between pixels in the part which does not impress electric field. On the other hand, when using polycrystalline silicon as an active element, it is not necessary to form a light-shielding film in an active element part. For this reason, the process which forms a light-shielding film can be abolished and productivity improves.

[0076] In addition, it can be used, if a light-shielding film is formed in the semi-conductor part even if it uses amorphous silicon. Although it is usually used as a transparent electrode, an electrode is good also as reflectors, such as chromium and aluminum, when using it as a liquid crystal display of a reflective mold.
[0077] In addition to this, the liquid crystal optical element used for this invention may carry out the laminating of an infrared cut filter, the ultraviolet-rays cut-off filter, etc., or may print an alphabetic character, a graphic form, etc., and the liquid crystal optical element of two or more sheets may be made to be used for it.
[0078] Furthermore, in this invention, the laminating of the guard plates, such as a glass plate and a plastic sheet, may be carried out to the outside of this liquid crystal optical element. Thereby, even if it pressurizes the front face, the danger of damaging becomes low and safety improves.
[0079] As a hardenability compound which constitutes the above-mentioned liquid crystal resin complex from this invention, when using a photoresist compound, use of a photo-curing vinyl system compound is desirable. Specifically, a photoresist acrylic compound is desirable.
[0080] When a photoresist compound is used, as for the liquid crystal of this invention, it is desirable to dissolve a photoresist compound in homogeneity. And the hardened material after optical exposure does not dissolve, or let it be what has the difficult dissolution. When using the constituent of liquid crystal, what has as near the solubility of each liquid crystal as possible is desirable.
[0081] It is not necessary to evaporate the mere solvent and the water which become unnecessary at the time of hardening in this invention by using liquid crystal as a solvent as liquid crystal resin complex, and stiffening a photoresist compound by optical exposure. For this reason, since it can harden by the sealing system, the manufacturing method of the impregnation to the conventional cel can adopt as it is, and dependability becomes high. Furthermore, since it also has the effectiveness of pasting up two substrates with a photoresist compound, dependability becomes high more.
[0082] In this invention, the danger that an up-and-down transparent electrode will short-circuit becomes low by considering as liquid crystal resin complex in this way. Furthermore, it is necessary to control neither orientation nor a substrate gap strictly like the display device of the usual TN mold, and the liquid crystal optical element which can control a transparency condition and a dispersion condition can be manufactured with very sufficient productivity.
[0083] The light source for projection, an incident light study system, a projection screen, etc. can use the light source for projection from the former, an incident light study system, and a projection screen, and should just arrange a liquid crystal display component between the light source for projection, and an incident light study system. Of course, the image of two or more liquid crystal display components is compounded using optical system, and you may make it display it. Moreover, a cooling system may be added to this or TV channel display of LED etc. may be added.
[0084] When displaying this projection mold especially, display contrast can be enlarged by installing the equipment which reduces the diffused light on an optical path, for example, an aperture and a spot as shown by 15 of drawing 2 .
[0085] Namely, the equipment which reduces the diffused light takes out the light (light in which the amount of picture element part penetrates the part of a transparency condition) which goes straight on to incident light among the light which passed the liquid crystal optical element, and should just reduce the light (light on which liquid crystal resin complex is scattered in the part of a dispersion condition) which does not go straight on. As for especially the light that goes straight on, it is desirable to reduce the light which does not go straight on, i.e., the diffused light, without reducing.
[0086] As concrete equipment, like drawing 1 , it consists of a liquid crystal display component and an incident light study system, and there are some which formed the liquid crystal display component 12, the condenser lens 16, the aperture which is the plate with which the hole opened and a spot 15, and the projector lens 17.
[0087] According to this example, it is condensed with a condenser lens 16, the light which goes straight on to incident light among the light which came out of the light source for projection, and passed the liquid crystal display component 12 passes the hole which was able to be opened in the aperture or the spot 15, and through projection of the projector lens 17 is carried out. On the other hand, the light which was scattered with the liquid crystal display component 12 and which does not go straight on does not pass the hole which was able to be opened in the aperture or the spot 15, even if condensed with a condenser lens 16. For this reason, it will not be projected on the scattered light and a contrast ratio improves.
[0088] Moreover, it can also be made to project through the projector lens which arranges aslant the mirror which has a small area instead of an aperture or a spot 15 as other examples in the same location, was made to reflect it in it, and has been arranged on the optical axis. Moreover, a spot, a mirror, etc. may be installed in the location to which a beam of light is extracted with a projector lens, without using such a condenser lens. Moreover, even if it does not use a special aperture etc., the focal distance of the lens for projection and aperture may be chosen so that the scattered light may be removed.
[0089] Moreover, a micro-lens system etc. can also be used. To the incident light study system side of a liquid crystal display component, a micro-lens array and the spot array by which the warm hole was array-ized can be

arranged, and, specifically, the unnecessary scattered light can be removed. In this case, since the optical path ength required for scattered-light removal can be shortened very much, it has the advantage that the whole projection mold display is made into a compact. It is also effective to incorporate the dispersion removal system which is equipment which reduces the diffused light in an incident light study system about compaction of the optical path length. In this case, while optical system becomes simple rather than it installs an incident light study system and a dispersion removal system independently, size can be stopped small.

[0090] Such optical system can perform composition of a mirror, a dichroic mirror, prism, a dichroic prism, a lens, etc. and a combination and an image, and colorization. Moreover, colorization of an image is possible also by combining with a color filter.

[0091] What is necessary is just to set up the ratio of the rectilinear-propagation component and dispersion component which reach on a projection screen so that it may be controllable and desired display contrast and display brightness can be obtained with the focal distance of paths, such as a spot and a mirror, and a lens.

[0092] When using the equipment which reduces the diffused light like drawing 1 , in order to raise the brightness of a display, the more parallel thing of the light by which incidence is carried out to a liquid crystal display component from the light source for projection is desirable. For that purpose, it is high brightness and it is desirable the light source near the point light source as much as possible and to constitute the light source for projection combining a concave mirror, a condenser lens, etc.

0093] Moreover, although the transparency mold liquid crystal display mainly explained in the above-mentioned explanation, you may be the projection mold liquid crystal display of a reflective mold. For example, a small mirror s arranged instead of a spot and only a required light can be taken out.

0094]

Example]

A nematic liquid crystal (deltan =0.24, deltaepsilon=11.8, K33 =15x10-12N, and eta=40cSt) and an acrylate nonomer forward in an example 1 dielectric anisotropy Two sorts (2-ethylhexyl acrylate, 2-hydroxyethyl acrylate), 2 organic-functions urethane acrylate oligomer ("UX4101" by Nippon Kayaku Co., Ltd.), and a photoreaction initiator were dissolved in homogeneity, and non-hardened mixture was manufactured. The molar fraction of the liquid crystal in mixture was 66wt(s)%.

0095] On the other hand, the seal of the active-matrix substrate with which polycrystalline silicon TFT was formed for every pixel, and the counterelectrode substrate with which the whole surface solid electrode was formed was carried out by the sealant arranged to the periphery, and the cel of 13 micrometers of electrode substrate gaps was formed.

0096] After injecting into this cel the mixture which is not hardened [above], it was made to harden by ultraviolet-rays exposure, and considered as liquid crystal resin complex. The driver voltage of this liquid crystal display component is abbreviation. It was 8V. the dielectric constant below the threshold electrical potential difference of this liquid crystal resin complex (measurement electrical-potential-difference = 0.3V) -- 1kHz -- about 8.2 it was .

0097] When this liquid crystal display component was driven with the video signal, the dynamic image which does not almost have printing at the time of the change of an image was obtained. moreover, the place which considered as the projection mold display combining this component, and the source of incident light and an incident light study system, and projected the image on the screen -- the contrast ratio on a screen -- about 10 it was . In addition, the converging angle (for converging-angle delta=2tan-1 (phi/2f) and phi, the diameter of n aperture and a spot and f are the focal distance of a lens) of an incident light study system is [full width]. It ould be 6 times.

0098] The mixture excluding liquid crystal from the aforementioned mixture is created, ultraviolet curing of this mixture is carried out, and it is thickness abbreviation. 500 micrometers and a film with a die length of about 5mm were manufactured. the place which measured the modulus of elasticity (dynamic modulus) of this film sing the viscoelasticity measuring device (cage en tech company make and LEO Vibron DDV mold) -- 20 degrees C 5x106 N/m2 and 40 degrees C 3x105 N/m2 it is -- it decreased in monotone to the rise of temperature.

0099] Moreover, the temperature used as the maximum of a loss modulus was -10 degrees C. In addition, the equency of 11Hz and a dynamic strain a Measuring condition 1% or less of sinusoidal amplitude is applied, and it a programming rate. It is measurement by hauling in a part for 3-degree-C/.

0100] Only the examples 1 and 2 of a comparison and an example 2 resin ingredient were replaced with, and the tive-matrix liquid crystal display component was created almost like the example 1.

0101] As an example 1 of a comparison, it is an example 1. 2 organic-functions urethane acrylate oligomer was placed with "M1200" by Toagosei. Driver voltage of this component It was 9V.

0102] As an example 2 of a comparison, example 1 differed from a part of monomer, and 2-ethylhexyl acrylate as replaced with 2 organic-functions acrylate monomer ("SR640" by Sartomer). The driver voltage of this mponent was 12V.

0103] one third of the oligomer "M1200" which a part of oligomer differed in the example 1 of a comparison, and

was used in the example 1 of a comparison as an example 2 It transposed to the hardenability resin which prepared the acryloyl radical in the both ends of molecular-weight about 3000 dimethylsiloxane, and liquid crystal resin complex was obtained. The driver voltage of this component was 10V.

[0104] These liquid crystal display components were driven with the video signal, and the seizure phenomenon at the time of the change of an image was investigated. Moreover, it considered as the projection mold display combining this component, and the source of incident light and an incident light study system, the image was projected on the screen, and the contrast ratio on a screen was measured. In addition, the converging angle of an incident light study system is [full width]. It could be 6 times.

[0105] The mixture excluding liquid crystal from three kinds of aforementioned mixture is created, ultraviolet curing of this mixture is carried out, and it is thickness abbreviation. 500 micrometers and a film with a die length of about 15mm were manufactured. The elastic modulus in 20 degrees C of this film and 40 degrees C was measured with the viscoelasticity measuring device.

[0106] Moreover, the temperature used as the maximum of the loss modulus resulting from the glass transition of a principal chain was measured. In addition, the Measuring condition was made to be the same as that of an example 1. Moreover, the magnitude (area of the hysteresis loop) of the hysteresis in the electrical-potential-difference-permeability property of this component was also measured.

[0107] These results are shown in Table 1. About the seizure phenomenon at the time of the change of an image, existence and an elastic modulus are N/m2, and the temperature used as the maximum of a loss modulus is **, and shows the magnitude of a hysteresis by the ratio to the magnitude (area of the hysteresis loop) of the hysteresis of an example 1. In addition, the elastic modulus all decreased in monotone to the rise of temperature from 20 degrees C to 40 degrees C.

[0108]

[Table 1]

	比較例1	比較例2	実施例2
1)焼付き現象	有	有	無
2)コントラスト比	110	70	80
3)弾性率：20℃	1×10^{8}	4×10^{8}	2×10^{6}
40℃	5×10^{6}	2×10^{7}	4×10^{5}
4)損失弾性率極大温度	11	22	-5
5)ヒステリシス比率	3	10	0.5

[0109]

[Effect of the Invention] In the projection mold liquid crystal display of this invention, as a liquid crystal ingredient pinched between the substrates with an electrode of the pair of the liquid crystal display component to be used, since the liquid crystal optical element which pinched the liquid crystal resin complex which can control a dispersion condition and a transparency condition electrically is used, a polarizing plate is unnecessary and the permeability of the light at the time of transparency can be improved sharply.

[0110] Also in the drive for which the projection mold liquid crystal display of this invention used IC for a drive or the conventional TN liquid crystal optical elements, it has a high contrast ratio and the display of high brightness is attained.

[0111] Furthermore, according to this invention, also when a gradation drive is performed, the gradation display out of which halftone came finely can be performed, and the printing phenomenon based on a hysteresis can be reduced. For this reason, the liquid crystal optical element of this invention is effective in a projection mold display, there is no printing of an image, and the bright good projection mold display of a contrast ratio is obtained. Moreover, the light source can also be miniaturized.

[0112] Moreover, since it is not necessary to use a polarizing plate, it also has the advantage that there are few wavelength dependencies of an optical property and the color correction of the light source etc. almost becomes needlessness. Moreover, since the trouble of destruction of the active element by orientation processing of rubbing indispensable to a TN liquid crystal optical element etc. or generating of static electricity accompanying it is also avoided, the manufacture yield of a liquid crystal optical element can be raised sharply.

[0113] Furthermore, since after hardening has become film-like, this liquid crystal resin complex cannot produce the trouble of destruction of the active element by the short circuit between substrates by the pressurization of a substrate, or migration of a spacer easily, either.

[0114] Moreover, this liquid crystal resin complex is equivalent to the case where specific resistance is in conventional TN mode, and does not need to prepare big storage capacitance for every pixel electrode like the conventional DS mode. For this reason, the design of an active element is easy, and it is easy to enlarge the rate

of an effective pixel electrode surface product, and the power consumption of a liquid crystal optical element can be kept few.

[0115] Furthermore, since manufacture becomes possible only by removing an orientation film formation process from the production process of the conventional liquid crystal optical element in TN mode, production is easy.

[0116] Moreover, the liquid crystal optical element using this liquid crystal resin complex also has the features that the response time is short, and the display of an animation is also easy for it. Furthermore, since the electro-optics property (electrical-potential-difference-permeability) of this liquid crystal optical element is a comparatively gently-sloping property as compared with the liquid crystal optical element in TN mode, application to a gradation display is also easy for it.

[0117] Moreover, as for the projection mold liquid crystal display of this invention, it is desirable to make it mostly in agreement [the refractive index of a resin matrix and the Tsunemitsu refractive index of liquid crystal]. Thereby, in the part which does not impress electric field, since light is scattered about, even if it does not shade any parts other than a pixel by the light-shielding film, there is no leakage of light at the time of projection, and it is not necessary to shade the gap between contiguity pixels.

[0118] For this reason, by using the active element by polycrystalline silicon as an active element especially, the light source for projection of high brightness without a light-shielding film can be used for an active element part, and the projection mold liquid crystal display of high brightness can be obtained easily. Furthermore in this case, a light-shielding film completely needs to be prepared, and a production process can be facilitated further.

[0119] Generally, liquid crystal solidification object complex can be used for a display device, and a high contrast ratio can be obtained by considering as a projection mold display further. It is because the scattered light and the rectilinear-propagation transmitted light are separable with optical system using directive high incident light.

[0120] However, when using the display device which consists of liquid crystal solidification object complex as a light valve of a projection mold indicating equipment, since it becomes the light of high density extremely, when the temperature in a display device rises or temperature unevenness arises, the factor which makes a contrast fall and degradation of the display grace of the display unevenness within the screen cause will produce incident light.

[0121] Moreover, in a projection mold display, since dispersion of light and a penetrable difference are projected on the display screen as it is, the hysteresis phenomenon of driver voltage pair transparency / dispersion property in the part of a display device will produce the seizure phenomenon on the display screen, and will spoil display grace remarkably.

[0122] Such a trouble is solvable with the configuration of the projection mold liquid crystal display by this invention. As mentioned above, by reducing a hysteresis, the delicate gradation nature in a high contrast display can also be expressed, and the high-definition image which is the high brightness which is not in the former, and has gradation nature can be offered. Furthermore, the display of high density is attained with combination with a active-matrix drive circuit etc.

[0123] In the range of the magnitude of the particle of the liquid crystal in the liquid crystal solidification object complex used by this invention, the fall of the resolution by control of light being transparency / dispersion mold does not pose a problem, but very good high resolution can be attained, and the projection mold display of high density is obtained by high brightness.

[0124] Application various by within the limits which does not lose the effectiveness of this invention is possible for this invention outside this.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the projection mold liquid crystal display using the liquid crystal optical element by which distributed maintenance of the liquid crystal was carried out into the resin matrix between the substrates with an electrode of a pair.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The liquid crystal display is widely used for the personal word processor, the hand held computer, Pocket TV, etc. in recent years taking advantage of the features, such as the low power and a low-battery drive. It is observed especially and the liquid crystal display component which has arranged the active element for every pixel electrode is developed briskly.

[0003] in the DSM mold, although the liquid crystal display component which used the liquid crystal of a DSM (dynamic scattering) mold was also proposed, since such a liquid crystal display component has the high current value which flows the inside of liquid crystal, there is a fault that the consumed electric current is large, what uses TN (the twist -- nematic) mold liquid crystal in current has become in use, and it has appeared in the commercial scene as a pocket TV at the beginning. In the TN liquid crystal, since the leakage current is very small and there is little power consumption, it is suitable for the application which uses a cell as a power source.

Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] In the projection mold liquid crystal display of this invention, as a liquid crystal ingredient pinched between the substrates with an electrode of the pair of the liquid crystal display component to be used, since the liquid crystal optical element which pinched the liquid crystal resin complex which can control a dispersion condition and a transparency condition electrically is used, a polarizing plate is unnecessary and the permeability of the light at the time of transparency can be improved sharply.

[0110] Also in the drive for which the projection mold liquid crystal display of this invention used IC for a drive for the conventional TN liquid crystal optical elements, it has a high contrast ratio and the display of high brightness is attained.

[0111] Furthermore, according to this invention, also when a gradation drive is performed, the gradation display out of which halftone came finely can be performed, and the printing phenomenon based on a hysteresis can be reduced. For this reason, the liquid crystal optical element of this invention is effective in a projection mold display, there is no printing of an image, and the bright good projection mold display of a contrast ratio is obtained. Moreover, the light source can also be miniaturized.

[0112] Moreover, since it is not necessary to use a polarizing plate, it also has the advantage that there are few wavelength dependencies of an optical property and the color correction of the light source etc. almost becomes needlessness. Moreover, since the trouble of destruction of the active element by orientation processing of rubbing indispensable to a TN liquid crystal optical element etc. or generating of static electricity accompanying it is also avoided, the manufacture yield of a liquid crystal optical element can be raised sharply.

[0113] Furthermore, since after hardening has become film-like, this liquid crystal resin complex cannot produce the trouble of destruction of the active element by the short circuit between substrates by the pressurization of a substrate, or migration of a spacer easily, either.

[0114] Moreover, this liquid crystal resin complex is equivalent to the case where specific resistance is in conventional TN mode, and does not need to prepare big storage capacitance for every pixel electrode like the conventional DS mode. For this reason, the design of an active element is easy, and it is easy to enlarge the rate of an effective pixel electrode surface product, and the power consumption of a liquid crystal optical element can be kept few.

[0115] Furthermore, since manufacture becomes possible only by removing an orientation film formation process from the production process of the conventional liquid crystal optical element in TN mode, production is easy.

[0116] Moreover, the liquid crystal optical element using this liquid crystal resin complex also has the features that the response time is short, and the display of an animation is also easy for it. Furthermore, since the electro-optics property (electrical-potential-difference-permeability) of this liquid crystal optical element is a comparatively gently-sloping property as compared with the liquid crystal optical element in TN mode, application to a gradation display is also easy for it.

[0117] Moreover, as for the projection mold liquid crystal display of this invention, it is desirable to make it mostly in agreement [the refractive index of a resin matrix and the Tsunemitsu refractive index of liquid crystal]. Thereby, in the part which does not impress electric field, since light is scattered about, even if it does not shade any parts other than a pixel by the light-shielding film, there is no leakage of light at the time of projection, and it is not necessary to shade the gap between contiguity pixels.

[0118] For this reason, by using the active element by polycrystalline silicon as an active element especially, the light source for projection of high brightness without a light-shielding film can be used for an active element part, and the projection mold liquid crystal display of high brightness can be obtained easily. Furthermore in this case, a light-shielding film completely needs to be prepared, and a production process can be facilitated further.

[0119] Generally, liquid crystal solidification object complex can be used for a display device, and a high contrast ratio can be obtained by considering as a projection mold display further. It is because the scattered light and the rectilinear-propagation transmitted light are separable with optical system using directive high incident light.

[0120] However, when using the display device which consists of liquid crystal solidification object complex as a light valve of a projection mold indicating equipment, since it becomes the light of high density extremely, when the temperature in a display device rises or temperature unevenness arises, the factor which makes a contrast

fall and degradation of the display grace of the display unevenness within the screen cause will produce incident light.

[0121] Moreover, in a projection mold display, since dispersion of light and a penetrable difference are projected on the display screen as it is, the hysteresis phenomenon of driver voltage pair transparency / dispersion property in the part of a display device will produce the seizure phenomenon on the display screen, and will spoil display grace remarkably.

[0122] Such a trouble is solvable with the configuration of the projection mold liquid crystal display by this invention. As mentioned above, by reducing a hysteresis, the delicate gradation nature in a high contrast display can also be expressed, and the high-definition image which is the high brightness which is not in the former, and has gradation nature can be offered. Furthermore, the display of high density is attained with combination with a active-matrix drive circuit etc.

[0123] In the range of the magnitude of the particle of the liquid crystal in the liquid crystal solidification object complex used by this invention, the fall of the resolution by control of light being transparency / dispersion mold does not pose a problem, but very good high resolution can be attained, and the projection mold display of high density is obtained by high brightness.

[0124] Application various by within the limits which does not lose the effectiveness of this invention is possible for this invention outside this.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] When using the liquid crystal display component which has arranged the active element in DS mode, the own leakage current of liquid crystal is large. For this reason, big storage capacitance had to be prepared in each pixel and juxtaposition, and it had the trouble that the power consumption of the liquid crystal display component itself became large.

[0005] In TN mode, since the own leakage current of liquid crystal is very small, it is not necessary to add big storage capacitance, and power consumption of the liquid crystal display component itself is made small. However, in TN mode, since two polarizing plates are needed, it has the trouble that the permeability of light is small. When performing color display especially using a color filter, it can use several% of the light which carries out incidence, and the strong light source will be needed, therefore power consumption will be made to increase as a result.

[0006] Moreover, in case an image is projected, the very strong light source is needed, and it has the trouble of the effect on the liquid crystal display component by that high contrast is hard to be acquired on a projection screen, and generation of heat of the light source.

[0007] Then, the liquid crystal resin complex which carried out distributed maintenance of the nematic liquid crystal into the resin matrix is used that the technical problem in TN mode should be solved, and the mode which can be driven by the low battery using the dispersion-transparency property not more than 10V is proposed.

[0008] However, in the conventional liquid crystal resin complex, the hysteresis existed in the electrical-potential-difference-permeability property, i.e., it has the technical problem that permeability differs at the time of a pressure up and pressure lowering, therefore there was a trouble that the printing phenomenon in which the information on a front screen will remain over several seconds or more at the time of change of the display screen might arise.

Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem]
[0005]
This invention can solve the above-mentioned technical problem by having the following configuration.
[0006]
In the printing system by which it is the printing system which consists of an airline printer and two or more information processors, and an information processor acquires and holds the information on an airline printer (1) Said information processor It has an information-requirements means to require information of said airline printer. Said airline printer It is the printing system which has an information response means to return information, to a demand of said information-requirements means from said information processor, and is characterized by said information processor having a notice means of information to notify said acquired information to other information processors.
[0007]
(2) In the control approach of a printing system that are the control approach of the printing system which consists of an airline printer and two or more information processors, and an information processor acquires and holds the information on an airline printer Said information processor has the information-requirements step which requires information of said airline printer. Said airline printer It is the printing system control approach which has the information response step which returns information to the demand of said information-requirements step from said information processor, and is characterized by said information processor having the notice step of information which notifies said acquired information to other information processors.
[0008]
It is the storage which stored the printing control program performed by the printing system which consists of an information processor and an airline printer. (3) Said information processor It has the information-requirements step which requires information of said airline printer. Said airline printer It has the information response step which returns information to the demand of said information-requirements step from said information processor. Said information processor It has the notice step of information which notifies said acquired information to other information processors. Said information processor The storage characterized by storing the control program of the printing system characterized by having the step which has an internal timer and makes information requirements an airline printer for every fixed time amount progress.

[Translation done.]

EXAMPLE

[Example]
A nematic liquid crystal (deltan =0.24, deltaepsilon=11.8, K33 =15x10-12N, and eta=40cSt) and an acrylate nonomer forward in an example 1 dielectric anisotropy Two sorts (2-ethylhexyl acrylate, 2-hydroxyethyl acrylate), 2 organic-functions urethane acrylate oligomer ("UX4101" by Nippon Kayaku Co., Ltd.), and a photoreaction initiator were dissolved in homogeneity, and non-hardened mixture was manufactured. The molar fraction of the liquid crystal in mixture was 66wt(s)%.
[0095] On the other hand, the seal of the active-matrix substrate with which polycrystalline silicon TFT was formed for every pixel, and the counterelectrode substrate with which the whole surface solid electrode was formed was carried out by the sealant arranged to the periphery, and the cel of 13 micrometers of electrode substrate gaps was formed.
[0096] After injecting into this cel the mixture which is not hardened [above], it was made to harden by ultraviolet-rays exposure, and considered as liquid crystal resin complex. The driver voltage of this liquid crystal display component is abbreviation. It was 8V. the dielectric constant below the threshold electrical potential difference of this liquid crystal resin complex (measurement electrical-potential-difference = 0.3V) -- 1kHz -- about 8.2 it was .
[0097] When this liquid crystal display component was driven with the video signal, the dynamic image which does not almost have printing at the time of the change of an image was obtained. moreover, the place which considered as the projection mold display combining this component, and the source of incident light and an incident light study system, and projected the image on the screen -- the contrast ratio on a screen -- about 10 it was . In addition, the converging angle (for converging-angle delta=2tan-1 (phi/2f) and phi, the diameter of an aperture and a spot and f are the focal distance of a lens) of an incident light study system is [full width]. It could be 6 times.
[0098] The mixture excluding liquid crystal from the aforementioned mixture is created, ultraviolet curing of this mixture is carried out, and it is thickness abbreviation. 500 micrometers and a film with a die length of about 5mm were manufactured. the place which measured the modulus of elasticity (dynamic modulus) of this film using the viscoelasticity measuring device (cage en tech company make and LEO Vibron DDV mold) -- 20 degrees C 5x106 N/m2 and 40 degrees C 3x105 N/m2 it is -- it decreased in monotone to the rise of temperature.
[0099] Moreover, the temperature used as the maximum of a loss modulus was -10 degrees C. In addition, the frequency of 11Hz and a dynamic strain a Measuring condition 1% or less of sinusoidal amplitude is applied, and it is a programming rate. It is measurement by hauling in a part for 3-degree-C/.
[0100] Only the examples 1 and 2 of a comparison and an example 2 resin ingredient were replaced with, and the active-matrix liquid crystal display component was created almost like the example 1.
[0101] As an example 1 of a comparison, it is an example 1. 2 organic-functions urethane acrylate oligomer was replaced with "M1200" by Toagosei. Driver voltage of this component It was 9V.
[0102] As an example 2 of a comparison, example 1 differed from a part of monomer, and 2-ethylhexyl acrylate was replaced with 2 organic-functions acrylate monomer ("SR640" by Sartomer). The driver voltage of this component was 12V.
[0103] one third of the oligomer "M1200" which a part of oligomer differed in the example 1 of a comparison, and was used in the example 1 of a comparison as an example 2 It transposed to the hardenability resin which prepared the acryloyl radical in the both ends of molecular-weight about 3000 dimethylsiloxane, and liquid crystal resin complex was obtained. The driver voltage of this component was 10V.
[0104] These liquid crystal display components were driven with the video signal, and the seizure phenomenon at the time of the change of an image was investigated. Moreover, it considered as the projection mold display combining this component, and the source of incident light and an incident light study system, the image was projected on the screen, and the contrast ratio on a screen was measured. In addition, the converging angle of an incident light study system is [full width]. It could be 6 times.
[0105] The mixture excluding liquid crystal from three kinds of aforementioned mixture is created, ultraviolet

curing of this mixture is carried out, and it is thickness abbreviation. 500 micrometers and a film with a die length of about 15mm were manufactured. The elastic modulus in 20 degrees C of this film and 40 degrees C was measured with the viscoelasticity measuring device.

[0106] Moreover, the temperature used as the maximum of the loss modulus resulting from the glass transition of a principal chain was measured. In addition, the Measuring condition was made to be the same as that of an example 1. Moreover, the magnitude (area of the hysteresis loop) of the hysteresis in the electrical-potential-difference-permeability property of this component was also measured.

[0107] These results are shown in Table 1. About the seizure phenomenon at the time of the change of an image, existence and an elastic modulus are N/m2, and the temperature used as the maximum of a loss modulus is **, and shows the magnitude of a hysteresis by the ratio to the magnitude (area of the hysteresis loop) of the hysteresis of an example 1. In addition, the elastic modulus all decreased in monotone to the rise of temperature from 20 degrees C to 40 degrees C.

[0108]

[Table 1]

	比較例1	比較例2	実施例2
1)焼付き現象	有	有	無
2)コントラスト比	110	70	80
3)弾性率：20℃	1×10^{8}	4×10^{8}	2×10^{6}
40℃	5×10^{6}	2×10^{7}	4×10^{5}
4)損失弾性率極大温度	11	22	-5
5)ヒステリシス比率	3	10	0.5

[Translation done.]

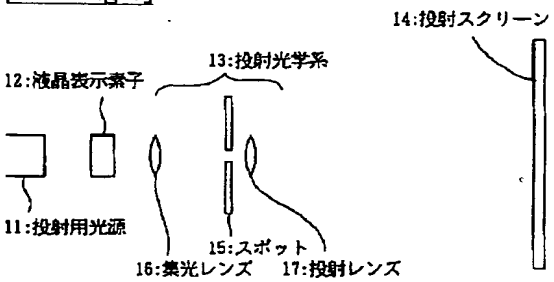
DESCRIPTION OF DRAWINGS

Brief Description of the Drawings]
Drawing 1] The mimetic diagram showing the fundamental configuration of the projection mold active-matrix liquid crystal display of this invention.
Drawing 2] The sectional view showing the fundamental configuration of the liquid crystal optical element used for this invention.
Description of Notations]
12: Liquid crystal optical element
Five : Substrate
: Pixel Electrode
: Active Element
: Counterelectrode
: Liquid Crystal Resin Complex
1 : Light Source for Projection
3 : Incident Light Study System
4 : Projection Screen
5 : Spot
6 : Condenser Lens
7 : Projector Lens

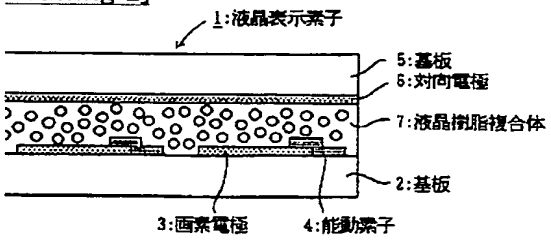
Translation done.]

DRAWINGS

[Drawing 1]



[Drawing 2]



Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平5－196925

(43)公開日　平成５年(1993)８月６日

(51)Int.Cl.[5]		識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｇ０２Ｆ	1/1333		9225－2K		
	1/13	５０５	8806－2K		

審査請求　未請求　請求項の数４(全 11 頁)

(21)出願番号　特願平4－298017
(62)分割の表示　特願平4－124236の分割
(22)出願日　平成４年(1992)４月17日

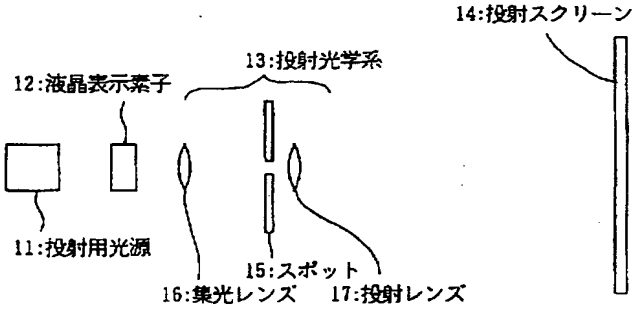
(31)優先権主張番号　特願平3－112562
(32)優先日　平３(1991)４月17日
(33)優先権主張国　日本（ＪＰ）

(71)出願人　000000044
旭硝子株式会社
東京都千代田区丸の内２丁目１番２号
(72)発明者　平井　良典
神奈川県横浜市神奈川区羽沢町松原1160番地　エイ・ジー・テクノロジー株式会社内
(72)発明者　新山　聡
神奈川県横浜市神奈川区羽沢町松原1160番地　エイ・ジー・テクノロジー株式会社内
(72)発明者　熊井　裕
神奈川県横浜市神奈川区羽沢町松原1160番地　エイ・ジー・テクノロジー株式会社内
(74)代理人　弁理士　泉名　謙治

最終頁に続く

(54)【発明の名称】　投射型液晶表示装置

(57)【要約】
【目的】液晶が樹脂マトリクス中に分散保持された液晶樹脂複合体を挟持した液晶光学素子のヒステリシスに基づく焼付き現象を防止し、美しい中間調表示の大スクリーンへの投射画像を得る。
【構成】光源、樹脂マトリクスを構成する樹脂材料の弾性率が、２０℃で3×10^{7} Ｎ／m^{2} 以下、４０℃で1×10^{3} Ｎ／m^{2} 以上となるような樹脂材料を用いた液晶表示素子、投射用光学系を組み合わせて投射型液晶表示装置を構成する。



1

【特許請求の範囲】

【請求項１】一対の電極付基板間に、液晶が樹脂マトリクス中に分散保持され、電圧印加時または非印加時のいずれか一方でその樹脂マトリクスの屈折率が使用する液晶の屈折率とほぼ一致し、他方で両屈折率が一致しないようにされ、さらに樹脂マトリクスを構成する樹脂材料の弾性率が20℃で 3×10^{7} N/m^{2} 以下、40℃で 1×10^{8} N/m^{2} 以上である液晶樹脂複合体を挟持してなる液晶光学素子と、投射用光源と、投射光学系とを組み合わせたことを特徴とする投射型液晶表示装置。

【請求項２】請求項１の投射型液晶表示装置において、液晶光学素子の樹脂マトリクスを構成する樹脂材料の損失弾性率の極大になる温度が、 0℃以下である液晶光学素子を用いたことを特徴とする投射型液晶表示装置。

【請求項３】請求項１または２の投射型液晶表示装置において、液晶光学素子の樹脂マトリクスを構成する樹脂材料が光硬化性ビニル系化合物を光硬化させたものである液晶光学素子を用いたことを特徴とする投射型液晶表示装置。

【請求項４】請求項１または２または３の投射型液晶表示装置において、液晶光学素子の一対の電極付基板として、画素電極毎に能動素子を設けたアクティブマトリクス基板と、対向電極を設けた対向電極基板とを用い、かつ、その間に挟持される液晶樹脂複合体として、正の誘電異方性を有するネマチック液晶が樹脂マトリクス中に分散保持され、その樹脂マトリクスの屈折率が使用する液晶の常光屈折率(n_o)とほぼ一致するようにされた液晶樹脂複合体を挟持してなる液晶光学素子を用いて、中間調を含む表示を行うことを特徴とする投射型液晶表示装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、一対の電極付基板間に、液晶が樹脂マトリクス中に分散保持された液晶光学素子を用いた投射型液晶表示装置に関する。

【０００２】

【従来の技術】液晶ディスプレイは、近年その低消費電力、低電圧駆動等の特長を生かしてパーソナルワードプロセッサー、ハンドヘルドコンピューター、ポケットＴＶ等に広く利用されている。なかでも注目され、盛んに開発されているのが、画素電極毎に能動素子を配置した液晶表示素子である。

【０００３】このような液晶表示素子は当初は、ＤＳＭ（動的散乱）型の液晶を用いた液晶表示素子も提案されていたが、ＤＳＭ型では液晶中を流れる電流値が高いため、消費電流が大きいという欠点があり、現在ではＴＮ（ツイストネマチック）型液晶を用いるものが主流となっており、ポケットＴＶとして市場に現われている。ＴＮ型液晶では、漏れ電流は極めて小さく、消費電力が少ないので、電池を電源とする用途には適している。

2

【０００４】

【発明が解決しようとする課題】能動素子を配置した液晶表示素子をＤＳモードで使用する場合には、液晶自身の漏れ電流が大きい。このため、各画素と並列に大きな蓄積容量を設けなくてはならなく、かつ、液晶表示素子自体の消費電力が大きくなるという問題点を有していた。

【０００５】ＴＮモードにおいては、液晶自身の漏れ電流は極めて小さいので、大きな蓄積容量を付加する必要はないし、液晶表示素子自体の消費電力は小さくできる。しかし、ＴＮモードでは、２枚の偏光板を必要とするので、光の透過率が小さいという問題点を有している。特に、カラーフィルターを用いてカラー表示を行う場合には、入射する光の数％しか利用できないこととなり、強い光源を必要とし、そのため結果として消費電力を増加させてしまう。

【０００６】また、画像の投影を行う際には極めて強い光源を必要とし、投影スクリーン上で高いコントラストが得られにくいことや、光源の発熱による液晶表示素子への影響という問題点を有している。

【０００７】そこで、ＴＮモードの課題を解決すべく、ネマチック液晶を樹脂マトリクス中に分散保持した液晶樹脂複合体を使用して、その散乱－透過特性を利用した10Ｖ以下の低電圧で駆動できるモードが提案されている。

【０００８】しかし、従来の液晶樹脂複合体においては、その電圧－透過率特性にヒステリシスが存在する、すなわち、昇圧時と降圧時において透過率が異なるという課題を有しており、そのため、表示画面の変化時に前画面の情報が数秒以上にわたって残ってしまうという焼付き現象が生ずることがあるという問題点があった。

【０００９】

【課題を解決するための手段】本発明は、高輝度、高コントラスト比を有し、中間調表示がきれいにでき、液晶樹脂複合体のヒステリシスに基づく焼付き現象を低減した液晶光学素子を用いた投射型液晶表示装置を提供するものである。

【００１０】即ち、一対の電極付基板間に、液晶が樹脂マトリクス中に分散保持され、電圧印加時または非印加時のいずれか一方でその樹脂マトリクスの屈折率が使用する液晶の屈折率とほぼ一致し、他方で両屈折率が一致しないようにされ、さらに樹脂マトリクスを構成する樹脂材料の弾性率が20℃で 3×10^{7} N/m^{2} 以下、40℃で 1×10^{8} N/m^{2} 以上である液晶樹脂複合体を挟持してなる液晶光学素子と、投射用光源と、投射光学系とを組み合わせたことを特徴とする投射型液晶表示装置、及び、液晶光学素子の樹脂マトリクスを構成する樹脂材料の損失弾性率の極大になる温度が、 0℃以下である液晶光学素子を用いたことを特徴とする投射型液晶表示装置、及び、液晶光学素子の樹脂マトリクスを構成する樹脂材料が光硬

化性ビニル系化合物を光硬化させたものである液晶光学素子を用いたことを特徴とする投射型液晶表示装置、及び、液晶光学素子の一対の電極付基板として、画素電極毎に能動素子を設けたアクティブマトリクス基板と、対向電極を設けた対向電極基板とを用い、かつ、その間に挟持される液晶樹脂複合体として、正の誘電異方性を有するネマチック液晶が樹脂マトリクス中に分散保持され、その樹脂マトリクスの屈折率が使用する液晶の常光屈折率(n_o)とほぼ一致するようにされた液晶樹脂複合体を挟持してなる液晶光学素子を用いて、中間調を含む表示を行うことを特徴とする投射型液晶表示装置を提供する。

【００１１】本発明によれば上記の構成をとることにより、ヒステリシスに基づく焼付き現象を低減し、かつ高コントラスト比を有し、低電圧で駆動できる投射型液晶表示装置を得ることができる。

【００１２】本発明では、一対の電極付基板間に、液晶が樹脂マトリクス中に分散保持され、電圧印加時または非印加時のいずれか一方でその樹脂マトリクスの屈折率が使用する液晶の屈折率とほぼ一致し、他方で両屈折率が一致しない液晶樹脂複合体を挟持して用いる。

【００１３】特に、正の誘電異方性を有するネマチック液晶が樹脂マトリクス中に分散保持され、その樹脂マトリクスの屈折率が使用する液晶の常光屈折率(n_o)とほぼ一致するようにされた液晶樹脂複合体を用いる。そして、液晶樹脂複合体を、画素電極毎に能動素子を設けたアクティブマトリクス基板と、対向電極を設けた対向電極基板との間に挟持する。

【００１４】この電極付基板とは、ガラス、プラスチック、セラミック等の基板上に電極が形成されたものをいう。通常この電極は、ＩＴＯ（In_2O_3-SnO_2）やSnO_2等の透明電極とされる。さらに必要に応じて、クロム、アルミニウム等の金属電極を併用してもよい。また、反射型で用いられる場合には、反射電極とされることもありうる。また、この一対の基板としては、アクティブマトリクス基板と対向電極基板との組み合わせもある。

【００１５】このアクティブマトリクス基板とは、基板上に電極と、薄膜トランジスタ（ＴＦＴ）、薄膜ダイオード、金属絶縁体金属非線形抵抗素子（ＭＩＭ）等の能動素子とが形成された基板である。この各画素電極には夫々に１個乃至複数個の能動素子が接続されている。また、この対向電極基板は、基板上に電極が形成され、アクティブマトリクス基板基板と組み合わせて、表示が可能なようにされている。

【００１６】この一対の電極基板間に、液晶樹脂複合体を挟持する。この液晶樹脂複合体は、電圧の印加状態により、液晶樹脂複合体中の液晶の屈折率が変化する。その樹脂マトリクスの屈折率が、液晶の屈折率とほぼ一致した時に、光が透過し、一致しない時に光が散乱する。これには、偏光板を用いていないので、明るい表示が容易に得られる。

【００１７】この際、その樹脂マトリクスの屈折率が使用する液晶の常光屈折率(n_o)とほぼ一致するようにされることにより、電圧を印加した時に光を透過し、電圧を印加しない時に光が散乱することになる。電圧印加時には、液晶分子が電界方向に平行に配列するので、屈折率が制御し易く、このタイプの素子は透過時に高い透過率が得られる。

【００１８】本発明の投射型液晶表示装置に用いる液晶光学素子は、それ自体、液晶表示素子として用いることもできる。また、調光窓や光シャッターとして用いることもできる。この液晶表示素子としては、直視型表示素子、投射型表示素子の両方で用いることができる。直視型表示素子として用いる場合、得たい表示特性に応じて、バックライト、レンズ、プリズム、ミラー、拡散板、光吸収体、カラーフィルターなどを組み合わせて表示装置を構成すればよい。

【００１９】本発明の投射型液晶表示装置は、液晶表示素子と、投射用光源、投射光学系などと組み合わせて、投射型液晶表示装置とする。投射用光源、投射光学系は従来から公知の投射用光源、レンズ等の投射光学系が使用でき、通常は上記液晶表示素子を投射用光源と投射レンズとの間に配置して用いればよい。

【００２０】本発明に用いる液晶光学素子では、一対の電極付基板間に、透過－散乱型の液晶樹脂複合体を挟持している。

【００２１】具体的には、本発明では、液晶光学素子として細かな孔の多数形成された樹脂マトリクスとその孔の部分に充填された液晶とからなる液晶樹脂複合体を用いる。この液晶樹脂複合体を一対の電極付基板間に挟持する。その電極間への電圧の印加状態によりその液晶の屈折率が変化し、樹脂マトリクスの屈折率と液晶の屈折率との関係が変化する。これら両者の屈折率が一致した時には透過状態となり、屈折率が異なった時には散乱状態となるような液晶表示素子が使用できる。

【００２２】この細かな孔の多数形成された樹脂マトリクスとその孔の部分に充填された液晶とからなる液晶樹脂複合体は、マイクロカプセルのような液泡内に液晶が封じ込められたような構造である。しかし、個々のマイクロカプセルが完全に独立していなくてもよく、多孔質体のように個々の液晶の液泡が細隙を介して連通していてもよい。

【００２３】本発明の投射型液晶表示装置に用いる液晶表示素子の液晶樹脂複合体は、次のようにして製造される。液晶と、樹脂マトリクスを構成する硬化性化合物とを混ぜ合わせて溶液状またはラテックス状にする。次いで、これを光硬化、熱硬化、溶媒除去による硬化、反応硬化等させて樹脂マトリクスを分離し、樹脂マトリクス中に液晶が分散した状態をとるようにすればよい。

【００２４】本発明では、この樹脂材料として、その弾

性率が20℃で 3×10^{7} N/m^{2} 以下、40℃で 1×10^{8} N/m^{2} 以上である樹脂材料を用いる。特に、使用温度域の多くの部分で上記範囲に入るようにされることが好ましい。これにより、ヒステリシスによる焼付き現象を低減することができる。さらに使用する硬化性化合物を、光硬化または熱硬化タイプにすることにより、密閉系内で硬化できるため好ましい。特に、光硬化タイプの硬化性化合物を用いることにより、熱による影響を受けなく、短時間で硬化させることができ好ましい。

【００２５】具体的な製法としては、従来の通常のネマチック液晶と同様にシール材を用いてセルを形成し、注入口から液晶と硬化性化合物との未硬化の混合物を注入し、注入口を封止して後、光照射をするか加熱して硬化させることもできる。

【００２６】また、本発明に用いる液晶光学素子の場合にはシール材を用いなく、例えば、透明電極を設けた基板上に、液晶と硬化性化合物との未硬化の混合物を供給し、その後、他方の電極付基板を重ねて光照射等により硬化させることもできる。

【００２７】もちろん、その後、周辺にシール材を塗布して周辺をシールしてもよい。この製法によれば、単に液晶と硬化性化合物との未硬化の混合物をロールコート、スピンコート、印刷、ディスペンサーによる塗布等の供給をすればよいため、注入工程が簡便であり、生産性が極めてよい。

【００２８】また、これらの液晶と硬化性化合物との未硬化の混合物には、基板間隙制御用のセラミック粒子、プラスチック粒子、ガラス繊維等のスペーサー、顔料、色素、粘度調整剤、その他本発明の性能に悪影響を与えない添加剤を添加してもよい。

【００２９】電圧印加時に透過状態になる素子に、この硬化工程の際に特定の部分のみに充分高い電圧を印加した状態で硬化させることにより、その部分を常に光透過状態にすることができるので、固定表示したいものがある場合には、そのような常透過部分を形成してもよい。逆に、電圧印加時に散乱状態になる素子を用いた場合には、同様にして常散乱部分を形成できる。

【００３０】なお、この液晶樹脂複合体を使用した液晶光学素子の透過状態での透過率は高いほどよく、散乱状態でのヘイズ値は80%以上であることが好ましい。

【００３１】本発明では、電圧を印加している状態で、樹脂マトリクス（硬化後の）の屈折率が、使用する液晶の常光屈折率(n_o)と一致するようにされることが好ましい。これにより、樹脂マトリクスの屈折率と液晶の屈折率とが一致した時に光が透過し、一致しない時に光が散乱（白濁）することになる。この素子の散乱性は、従来のＤＳモードの液晶表示素子の場合よりも高く、高いコントラスト比の表示が得られる。

【００３２】本発明の最も大きな目的は、液晶樹脂複合体のヒステリシスに基づく焼付き現象を低減し、かつ低電圧で駆動できる液晶光学素子を用いて投射型液晶表示装置を提供するものである。この液晶光学素子は、能動素子と組み合わせることにより、高密度表示というより高い機能を発現することができる。もちろんこのほか、中間調の必要な他の用途（窓、シャッター、ディスプレイ、空間変調器など）においても、その機能は有効に発揮できる。

【００３３】従来の液晶樹脂複合体においては、電圧－透過率特性にヒステリシスが存在しそれが階調表示をする際の問題点となっていた。ヒステリシスとは、電圧を上昇する過程と電圧を降下させる過程において透過率が異なるといった現象である。ヒステリシスが存在すると、階調表示の際に前画面の情報が残ってしまう、即ち、画像が焼付くという現象が生じ、これが、画質を低下させていた。

【００３４】液晶樹脂複合体においてヒステリシスが存在する原因の一つは、液晶樹脂複合体が、液晶が樹脂中に分散保持されているという構造による。即ち、分離して樹脂中に存在する液晶同士の相互作用によってヒステリシスが存在すると考えられる。このヒステリシスの大小は、樹脂中に保持される液晶中に蓄えられる弾性的エネルギー、外から印加される電界による電気的エネルギーと、分離して樹脂中に存在する液晶同士の相互作用エネルギーによって決定されるものである。従って、このエネルギーバランスを最適化することによってヒステリシスは低減することができ、階調表示の際にも焼付きのない優れた表示を得ることができる。

【００３５】本発明の目的は、高いコントラスト比、高い輝度、優れた応答性を有し、ヒステリシスを低減した液晶光学素子を用いた液晶表示装置を得ることである。さらには、従来のＴＮ用の能動素子や駆動回路で駆動できる液晶光学素子を用いた液晶表示装置を得ることである。

【００３６】上記のエネルギーバランスを決定する重要な要因は、樹脂中に分散保持される液晶の平均粒子径Ｒ、液晶粒子の形状、液晶の誘電率並びにその異方性Δε、液晶の弾性定数、樹脂マトリクスの弾性率、誘電率などである。上記の目的のため最適化を行う場合、このエネルギーバランスが素子の電圧－透過率特性、液晶の動的特性（応答性）とも密接に関連していることを考慮して最適化を行うことが重要である。

【００３７】上記のエネルギーバランスにおいて、樹脂マトリクスの弾性的性質は、液晶配列の安定性という点で、重要な役割を果たす。用いる液晶の持つ弾性定数と比して充分に大きな弾性率をマトリクスが持つ場合（液晶よりもマトリクスが充分に硬い場合）、電界の印加により液晶が再配列する際に、マトリクスの変形はほとんど生じない。このため、無電界時の液晶粒子形状のまま液晶自体の電気的、弾性的エネルギーにより液晶配列は決定される。

【００３８】一方、電界印加による液晶再配列の際に、マトリクス自体の変形を生ずる場合には、液晶自体の電気的、弾性的エネルギーと、マトリクスの弾性的エネルギーにより、液晶配列は決定される。一般に、液晶の弾性定数は10^{-11} N程度であり、また液晶粒子の平均的直径は 1～ 3μｍ程度である。このため、マトリクスの弾性率が10^{7} N/m^{2} 程度もしくはそれよりも小さい場合に、マトリクスの変形がエネルギー的に寄与するようになる。このような柔かいマトリクスにおいては、印加された電界に応じてマトリクスの変形をともなって液晶の再配列が起こる。

【００３９】ヒステリシスの１つの要因として、それぞれの液晶粒子における液晶の配列変化がその場所の誘電率の大きな変化を生ずることが挙げられる。この誘電率変化は他の液晶粒子の場所に対して電界の変化を生じさせる。このため、系に分散する液晶粒子中の液晶配列が、外部からのある印加電圧に対して一意的には決まらないといった現象が生ずる。

【００４０】この観点から、液晶の配列の変化時に、マトリクスの形状が変形し得る、即ち、柔かいということが望ましい。充分に硬いマトリクスにおいては、液晶とマトリクスの境界面が固定されていることになる。これにより、印加電界の上昇にともないある電界において急激な配列の変化（フレデリクス転移）が生じる。このため、これが大きな誘電率変化を起こし、ヒステリシスを生ずる要因となる。

【００４１】一方、充分に柔かいマトリクスにおいては、液晶配列の急激な変化は生じにくく、マトリクスの変形により、印加されている電界に対して液晶の配列は安定化され、ヒステリシスは低減される。また、充分に柔かいマトリクスにおいては、外部から小さな電気的エネルギーを加えることにより、液晶の配列変化とマトリクスの変形が起こりうる。このため、ヒステリシスの低減と低電圧での駆動が同時に達成しやすいという利点をも持つ。

【００４２】以上に述べたことより、マトリクスを構成する樹脂材料の弾性率としては、20℃で 3×10^{7} N/m^{2} 以下である。特に、 1.5×10^{7} N/m^{2} 以下が好ましい。

【００４３】マトリクスの弾性率が低すぎる場合には、マトリクスの構造安定性に問題を生じたり、電界のオン、オフの際に、液晶配列を復元させる充分な力が働かないといった問題が生じたりする。このため、マトリクスの弾性率は下限を有しており、40℃で 1×10^{4} N/m^{2} 以上とされる。通常の室温程度で使用される場合には、20～40℃の温度域で、 3×10^{7} N/m^{2} ～ 1×10^{7} N/m^{2} とされる。特に、 5×10^{6} N/m^{2} 以上がより好ましい。

【００４４】また、ヒステリシスの低減を実用的な温度範囲で達成するためには、マトリクスのガラス転移温度は使用温度域よりも充分に低いことが好ましい。具体的には、液晶樹脂複合体の樹脂マトリクスを構成する樹脂材料の主鎖のガラス転移に起因した損失弾性率の極大となる温度が、使用温度域よりも低いことが好ましい。一般的には、損失弾性率の極大となる温度が 0℃以下であることが好ましい。

【００４５】なお、ここでいう樹脂材料とは、液晶を含まない樹脂材料そのものをさす。また、弾性率は、11Hz、動的歪が 1%以下の正弦波振幅を加え、昇温速度 3℃／分で、引っ張り時の粘弾性測定により得られた動的貯蔵弾性率で定義する。

【００４６】樹脂マトリクスの樹脂部分は、樹脂のみで構成されていても、液晶で膨潤した樹脂で構成されてもよい。液晶で膨潤している場合には、一般に、液晶樹脂複合体としてのガラス転移温度は、樹脂単体の場合よりも低温度域にシフトし、また、絶対的な弾性率も低下する。従って、上記の範囲の望ましい樹脂材料をマトリクス構成材料として用い、更に、液晶による膨潤を利用することにより、より細かなマトリクス弾性率の制御が可能である。マトリクス中に膨潤する液晶量は、用いる液晶材料、樹脂材料により異なり、樹脂材料に対して、 0～数十wt%の膨潤量を取ることができる。

【００４７】従って、液晶で膨潤したマトリクスの弾性率としては、一般に、上記の樹脂のみの場合の弾性率よりも低い範囲で規定され、20℃で 8×10^{6} N/m^{2} 以下が好ましく、特に、 4×10^{6} N/m^{2} 以下がより好ましい。また、下限としては、40℃で10^{3} N/m^{2} 以上とされ、 2×10^{3} N/m^{2} 以上がより好ましい。また、液晶樹脂複合体の液晶で膨潤したマトリクスの損失弾性率の極大となる温度は、-5℃以下であることが好ましい。

【００４８】一方、樹脂が-(Si(CH$_3$)$_2$-O-)$_n$-（ポリシロキサン構造）や、-C$_6$H$_{12}$-（ヘキサメチレン構造）等を含むことで、そのガラス転移温度を低下させることが可能であり、ここで用いる樹脂の一部にこのような構造を設けてもよい。

【００４９】さらに、１分子中の硬化部位の数としては 1～10のものが選ばれるが、構造の安定性という意味で 2～ 6官能のものを、マトリクスを構成する樹脂の 5wt%以上用いることが好ましい。さらには、液晶樹脂複合体の液晶粒子径、粒子径分布、粒子密度などを制御するためには、分子量の異なる２種以上の硬化性化合物を混合して用いることが好ましく、それらの分子量の最大のものと最小のものとの比が、 1.5倍以上あるものが好ましい。

【００５０】具体的な製造方法としては、硬化後に上記物性範囲を満たす硬化性化合物を液晶材料と均一に溶解させ、硬化性化合物の硬化により液晶と樹脂マトリクスの相分離構造を形成させる手法などが挙げられる。この際、他の硬化性化合物や反応開始剤等を適宜混合することにより硬化前後の系の相溶性のバランスとマトリクスの特性を制御することが可能である。特に、光硬化性ビニル系化合物を用い、光照射により相分離構造を形成す

ることは、構造制御、生産性の両面から望ましいものである。この場合、アクリル系樹脂、特に、官能基としてアクリル基を持つものが望ましい。

【００５１】液晶粒子が樹脂マトリクス中に分散していることに伴うヒステリシスを低減するには、液晶の誘電率、その異方性Δε並びに樹脂マトリクスの誘電率のバランスを取ることも重要である。また、液晶の粒子の形状も、重要な因子である。これら、他の要因とのバランスを取ることによって、本発明の効果は強めることが可能である。使用する液晶の誘電異方性Δεとしては、

$5 < \Delta\varepsilon < 13$

の関係を満たすことが好ましい範囲である。

【００５２】Δεは、ヒステリシス並びに駆動電圧双方と関係する量であり、上限は、ヒステリシスの大きさより、下限は駆動電圧より決められる。この条件はΔεが大きいほど駆動電圧が低くなるという従来のＴＮ型液晶表示素子の常識からは一見不利に見える。しかし、このような液晶粒子の分散した系においては、駆動電圧がΔεの平方根に反比例するという従来のＴＮ型液晶表示素子の概念は成立しない。

【００５３】これは、液晶部分とマトリクス部分への電圧配分が液晶の配列により異なるためである。一般にこのような系では、Δεは駆動電圧にあまり大きな影響は示さず、Δεが5より大きな範囲では、Δεを小さくすることにより駆動電圧が極めて高くなるということはない。

【００５４】また、ヒステリシスの低減には、液晶樹脂複合体のしきい値電圧以下の充分に低い電圧に対する誘電率ε_0と、使用する液晶の誘電率異方性Δεが、

$\Delta\varepsilon < 1.45 \cdot \varepsilon_0$

の関係を持つことが好ましい。

【００５５】Δεがこの範囲より大きいと、１つの液晶粒子内の液晶の動きがその粒子内の大きな誘電率変化となる。その結果、その粒子の周辺に大きな電界変化を生じさせる。このため、ヒステリシスを引き起こす要因である液晶粒子間の電気的相互作用が大きくなってしまう。ε_0は、樹脂マトリクスの誘電率とも関係する量であり、樹脂マトリクスの誘電率が増大すると、液晶樹脂複合体全体の誘電率ε_0は増大し、取りうるΔεの範囲も広がる。

【００５６】本発明で使用する液晶は、ネマチック液晶またはスメクチック液晶が使用できるが、ネマチック液晶の使用が好ましい。また、その一部にコレステリック液晶を添加したり、２色性色素や単なる色素を添加したりしてもよい。さらに、これに粘度調整剤、アルミナ粒子やガラス繊維等のスペーサー、その他添加剤等を加えてもよい。

【００５７】液晶の屈折率異方性Δnも、電気光学特性を決める重要な要因である。電界をかけない状態での散乱性を大きく取るためには、使用する液晶の屈折率異方性が0.18以上であることが好ましく、特には0.20以上がより好ましい。

【００５８】本発明では、電圧印加時に液晶と樹脂マトリクスの屈折率が一致するようにすることにより、透過時の透過率が高くなるので好ましい。このため、正の誘電異方性のネマチック液晶を使用し、液晶の常光屈折率(n_0)が樹脂マトリクスの屈折率n_pとほぼ一致するようすることが好ましい。この時、電圧印加時に高い透明性が得られる。具体的には$n_0 - 0.03 < n_p < n_0 + 0.05$の関係を満たすことが好ましい。

【００５９】樹脂マトリクス中に分散保持される液晶は、独立した粒子、または一部が連通した粒子であることが好ましい。これは、高い散乱能と低電圧で駆動した際の高い透過性を両立するために有効である。散乱は液晶と樹脂の界面の存在により引き起こされる。このため、この界面の面積が大きいほど散乱性は向上する。

【００６０】ある最適な平均粒子径で、この界面の面積を増大させるためには、独立して樹脂と分離した液晶量を多くする、即ち、液晶粒子密度を多くすることが重要である。しかし、樹脂と分離した液晶量を増大していくと、いずれ夫々の液晶粒子が連通するようになり、さらには液晶が全て連通した構造を取るようになる。これは樹脂と分離した液晶界面の喪失につながるため、散乱能の低下につながる。

【００６１】また、駆動電圧を低くするためには、樹脂中に保持される夫々の液晶がほぼ等しい駆動電界を持つことが重要である。このためには、液晶が明確な界面を樹脂との間に持つ方が有利であり、界面の喪失は駆動電界の分散につながり、コントラスト比の低下と駆動電圧の上昇を生じる傾向がある。このため、樹脂中に分散保持される液晶は、高密度に存在する独立粒子または一部が連通した粒子であることが好ましい。

【００６２】上記の説明では、単独の液晶光学素子の場合を説明している。投射型液晶表示装置等に用いるように、例えば３個の液晶表示素子を用い、ＲＧＢ３色の光を各液晶表示素子に分けて透過させる場合には、各色毎に液晶の粒径、基板間隙、液晶の屈折率等を調整して、各色毎にその特性を揃えておくことが好ましい。

【００６３】また、無電界時の散乱性を向上させるには、液晶樹脂複合体の動作可能な液晶の体積分率Φを増加させることが有効である。具体的にはΦ＞20%が好ましく、より高い散乱性を有するにはΦ＞35%が好ましく、さらにはΦ＞45%が好ましい。一方Φがあまり大きくなると、液晶樹脂複合体の構造安定性が悪くなるため、Φ＜70%が好ましい。

【００６４】本発明での液晶光学素子は、その樹脂マトリクスの屈折率が使用する液晶の常光屈折率(n_0)とほぼ一致するようにすることが好ましい。この場合、電圧が印加されていない場合は、強制的に基板に垂直方向に配列していない液晶と、樹脂マトリクスの屈折率の違いに

より、散乱状態（つまり白濁状態）を示す。このため、電極のない部分は光が散乱される。

【0065】この液晶光学素子を投射型表示装置として用いる場合には、画素部分以外の部分は光が散乱されるので、遮光膜を設けなくても、光が投射スクリーンに到達しないため、黒く見える。このことにより、画素電極以外の部分からの光の漏れを防止するために、画素電極以外の部分を遮光膜等で遮光する必要がない。このため、遮光膜の形成工程が不要となるという利点も有する。

【0066】これに所望の画素に電界を印加する。この電界を印加された画素部分では、液晶が配列し、液晶の常光屈折率(n_o)と樹脂マトリクスの屈折率(n_p)とが一致する。これにより透過状態を示し、当該所望の画素で光が透過することとなり、投射スクリーンに明るく表示される。

【0067】この素子に、この硬化工程の際に特定の部分のみに充分に高い電圧を印加した状態で硬化させることにより、その部分を常に光透過状態とすることができる。固定表示したいものがある場合にはそのような常透過部分を形成してもよい。

【0068】また、本発明での液晶表示素子は、カラーフィルターを設けることによりカラー表示を行うことができる。このカラーフィルターは、1個の液晶表示素子に3色設けてもよいし、1個の液晶表示素子に1色設けてもこれを3個組み合わせてもよい。このカラーフィルターは、基板の電極面側に設けてもよいし、外側に設けてもよい。

【0069】また、液晶樹脂複合体中に染料、顔料等を混入しておくことにより、カラー表示を行うようにしてもよい。

【0070】図1は、図2に示す液晶表示素子を用いた投射型液晶表示装置の模式図である。図1において、11は投射用光源、21は液晶表示素子、13はレンズ、アパーチャー等を含む投射光学系、14は投射する投射スクリーンを示している。なお、投射光学系はこの例では、孔のあいた板であるアパーチャーやスポット15、集光レンズ16、投射レンズ17を含んでいる。

【0071】図2は、本発明での液晶表示素子の1例における断面図であり、アクティブマトリクス基板を使用した場合の断面図である。図2において、1は液晶表示素子、2はアクティブマトリクス基板用のガラス、プラスチック等の基板、3はＩＴＯ（In_2O_3-SnO_2）、SnO_2等の画素電極、4はトランジスタ、ダイオード、非線形抵抗素子等の能動素子、5は対向電極基板用のガラス、プラスチック等の基板、6はＩＴＯ、SnO_2等の対向電極、7は両基板間に挟持された液晶樹脂複合体を示している。

【0072】能動素子としてＴＦＴ（薄膜トランジスタ）等の3端子素子を使用する場合、対向電極基板は全画素共通のベタ電極を設ければよい。ＭＩＭ素子、ＰＩＮダイオード等の2端子素子を用いる場合には、対向電極基板はストライプ状のパターニングをされる。

【0073】また、能動素子として、ＴＦＴを用いる場合には、半導体材料としてはシリコンが好適であり得る。特に多結晶シリコンは、非結晶シリコンのように感光性がないため、光源からの光を遮光膜により遮光しなくてもまたは厳密な遮光膜でなくても誤動作しにくく、好ましい。この多結晶シリコンは、本発明のように投射型液晶表示装置として用いる場合、強い投射用光源を利用でき、明るい表示が得られる。

【0074】また、従来のＴＮ型液晶光学素子の場合には、画素間からの光の漏れを抑止するために、画素間に遮光膜を形成することが多い。この際に、ついでに能動素子部分にも同時遮光膜を形成することができる。このため、能動素子部分に遮光膜を形成することは全体の工程にあまり影響を与えない。即ち、能動素子として多結晶シリコンを用いて、能動素子部分に遮光膜を形成しないことにしても、画素間に遮光膜を形成する必要があれば、工程を減らすことはできない。

【0075】これに対して、本発明では、前述の如く、樹脂マトリクスの屈折率が使用する液晶の常光屈折率(n_o)とほぼ一致するようにされた液晶樹脂複合体を使用することが好ましい。これにより、電界を印加しない部分では光が散乱して投射された投射スクリーン上では黒くなるため、画素間に遮光膜を形成しなくてよい。一方、能動素子として多結晶シリコンを用いる場合、能動素子部分に遮光膜を形成しなくてもよい。このため、遮光膜を形成する工程をなくすことができ、生産性が向上する。

【0076】なお、非結晶シリコンを用いても、その半導体部分に遮光膜を形成すれば、使用することができる。電極は通常は透明電極とされるが、反射型の液晶表示装置として使用する場合には、クロム、アルミニウム等の反射電極としてもよい。

【0077】本発明に用いる液晶光学素子は、このほか赤外線カットフィルター、紫外線カットフィルター等を積層したり、文字、図形等を印刷したりしてもよいし、複数枚の液晶光学素子を用いたりするようにしてもよい。

【0078】さらに、本発明では、この液晶光学素子の外側にガラス板、プラスチック板等の保護板を積層してもよい。これにより、その表面を加圧しても、破損する危険性が低くなり、安全性が向上する。

【0079】本発明では、前述の液晶樹脂複合体を構成する硬化性化合物として、光硬化性化合物を用いる場合、光硬化ビニル系化合物の使用が好ましい。具体的には、光硬化性アクリル系化合物が好ましい。

【0080】本発明の液晶は、光硬化性化合物を用いた場合には、光硬化性化合物を均一に溶解することが好ましい。そして、光露光後の硬化物は溶解しない、もしく

は溶解困難なものとされる。液晶の組成物を用いる場合は、個々の液晶の溶解度ができるだけ近いものが望ましい。

【００８１】本発明では、液晶樹脂複合体として液晶を溶媒として使用し、光露光により光硬化性化合物を硬化させることにより、硬化時に不要となる単なる溶媒や水を蒸発させる必要がない。このため、密閉系で硬化できるため、従来のセルへの注入という製造法がそのまま採用でき、信頼性が高くなる。さらに、光硬化性化合物で２枚の基板を接着する効果も有するため、より信頼性が高くなる。

【００８２】本発明では、このように液晶樹脂複合体とすることにより、上下の透明電極が短絡する危険性が低くなる。さらに、通常のＴＮ型の表示素子のように配向や基板間隙を厳密に制御する必要もなく、透過状態と散乱状態とを制御しうる液晶光学素子を極めて生産性良く製造できる。

【００８３】投射用光源、投射光学系、投射スクリーン等は従来からの投射用光源、投射光学系、投射スクリーンが使用でき、投射用光源と投射光学系との間に液晶表示素子を配置すればよい。もちろん、複数の液晶表示素子の像を光学系を用いて合成して表示するようにしてもよい。また、これに冷却系を付加したり、ＬＥＤ等のＴＶチャンネル表示等を付加したりしてもよい。

【００８４】特に、この投射型の表示をする場合、光路上に拡散光を減ずる装置、例えば、図２の15で示されるようなアパーチャーやスポットを設置することにより、表示コントラストを大きくすることができる。

【００８５】即ち、拡散光を減ずる装置とは、液晶光学素子を通過した光の内、入射光に対して直進する光（画素部分が透過状態の部分を透過する光）を取り出し、直進しない光（液晶樹脂複合体が散乱状態の部分で散乱される光）を減ずるものであればよい。特に、直進する光は減ずることなく、直進しない光、即ち、拡散光を減ずることが好ましい。

【００８６】具体的な装置としては、図１のように、液晶表示素子と投射光学系とで構成され、液晶表示素子12、集光レンズ16、孔のあいた板であるアパーチャーやスポット15、投射レンズ17を設けたものがある。

【００８７】この例によれば、投射用光源からでて液晶表示素子12を通過した光のうち、入射光に対して直進する光は集光レンズ16により集光され、アパーチャーやスポット15に開けられた孔を通過して、投射レンズ17を通し投射される。一方、液晶表示素子12で散乱させられた直進しない光は、集光レンズ16により集光されても、アパーチャーやスポット15に開けられた孔を通過しない。このため、散乱光が投射されないことになり、コントラスト比が向上する。

【００８８】また、他の例としては、アパーチャーやスポット15の代りに、小さな面積を有する鏡を同じ位置に斜めに配置し、反射させてその光軸上に配置された投射レンズを通して投射させることもできる。また、このような集光レンズを用いることなく、投射レンズにより光線が絞られる位置にスポット、鏡等を設置してもよい。また、特別なアパーチャー等を用いなくとも、投射用レンズの焦点距離、口径を、散乱光が除去されるように選択してもよい。

【００８９】また、マイクロレンズ系なども用いることもできる。具体的には、液晶表示素子の投射光学系側にマイクロレンズアレイと細やかな穴がアレイ化されたスポットアレイを配置して、不要な散乱光を除去することができる。この場合、散乱光除去に必要な光路長を非常に短くすることができるため全体の投射型表示装置をコンパクトにできるという利点を持つ。光路長の短縮に関しては、投射光学系の中に拡散光を減ずる装置である散乱除去系を組み込むことも有効である。この場合、独立に投射光学系と散乱除去系を設置するより光学系がシンプルになると共に、サイズを小さく抑えることができる。

【００９０】これらの光学系は、ミラー、ダイクロイックミラー、プリズム、ダイクロイックプリズム、レンズなどと組合せ、画像の合成、カラー化ができる。また、カラーフィルターと組み合わせることによっても画像のカラー化が可能である。

【００９１】投射スクリーン上に到達する直進成分と散乱成分との比は、スポット、鏡等の径及びレンズの焦点距離により制御可能で、所望の表示コントラスト、表示輝度を得られるように設定すればよい。

【００９２】図１のような拡散光を減ずる装置を用いる場合、表示の輝度を上げるためには、投射用光源から液晶表示素子に入射される光はより平行であることが好ましい。そのためには、高輝度でかつできるだけ点光源に近い光源と、凹面鏡、コンデンサーレンズ等を組み合わせて投射用光源を構成することが好ましい。

【００９３】また、上記の説明では、主として透過型液晶表示装置で説明したが、反射型の投射型液晶表示装置であってもよい。例えば、スポットの代りに小型の鏡を配置して必要な光のみを取り出すようにすることができる。

【００９４】

【実施例】

実施例１

誘電異方性が正のネマチック液晶（$\Delta n = 0.24$、$\Delta \varepsilon = 11.8$、$K33 = 15 \times 10^{-12}$ N、$\eta = 40$cSt）とアクリレートモノマー２種（2-エチルヘキシルアクリレート、2-ヒドロキシエチルアクリレート）、２官能ウレタンアクリレートオリゴマー（日本化薬社製「UX4101」）、光反応開始剤を、均一に溶解し、未硬化の混合物を製造した。混合物における液晶の分率は66wt％であった。

【００９５】一方、多結晶シリコンＴＦＴが画素毎に形

成されたアクティブマトリクス基板と、全面ベタ電極が形成された対向電極基板とを、周辺部に配置したシール材でシールして、電極基板間隙13μｍのセルを形成した。

【００９６】このセルに、前記の未硬化の混合物を注入した後、紫外線露光により硬化させ、液晶樹脂複合体とした。この液晶表示素子の駆動電圧は約 8Ｖであった。この液晶樹脂複合体のしきい値電圧以下（測定電圧＝0.3Ｖ）の誘電率は、1KHzで約8.2 であった。

【００９７】この液晶表示素子をビデオ信号で駆動したところ、画像の切り替え時にも焼付きのほとんどない動画像が得られた。また、この素子と、投射光源、投射光学系を組み合わせて投射型表示装置とし、スクリーン上に画像の投影を行ったところ、スクリーン上のコントラスト比は約110 であった。なお、投射光学系の集光角（集光角 $\delta=2\tan^{-1}(\Phi/2f)$、Φはアパーチャー、スポットの直径、 fはレンズの焦点距離）は全角で 6度とした。

【００９８】前記の混合物から液晶を除いた混合物を作成し、この混合物を紫外線硬化させて、厚さ約 500μｍ、長さ約15mmのフィルムを製造した。このフィルムの弾性率（動的弾性率）を粘弾性測定装置（オリエンテック社製、レオバイブロンDDV 型）を用いて測定したところ、20℃で 5×10^{9} N/m^2 、40℃で 3×10^{5} N/m^2 であり、温度の上昇に対して単調に減少した。

【００９９】また、損失弾性率の極大となる温度は、－10℃であった。なお、測定条件は、周波数11Hz、動的歪が 1%以下の正弦波振幅を加え、昇温速度 3℃／分で引っ張りによる測定である。

【０１００】比較例１、２、実施例２
樹脂材料のみを代えて、実施例１とほぼ同様に、アクティブマトリクス液晶表示素子を作成した。

【０１０１】比較例１としては、実施例１の 2官能ウレタンアクリレートオリゴマーを、東亜合成社製「M1200 」に代えた。この素子の駆動電圧は 9Ｖであった。

＊【０１０２】比較例２としては、実施例１とモノマーの一部が異なり、2-エチルヘキシルアクリレートを、 2官能アクリレートモノマー（サートマー社製「SR640 」）に代えた。この素子の駆動電圧は、12Ｖであった。

【０１０３】実施例２としては、比較例１とはオリゴマーの一部が異なり、比較例１で用いたオリゴマー「M1200 」の1/3 を分子量約3000のジメチルシロキサンの両末端にアクリロイル基を設けた硬化性樹脂に置き換えて液晶樹脂複合体を得た。この素子の駆動電圧は、10Ｖであった。

【０１０４】これらの液晶表示素子をビデオ信号で駆動し、画像の切り替え時の焼付き現象を調査した。また、この素子と、投射光源、投射光学系を組み合わせて投射型表示装置とし、スクリーン上に画像の投影を行い、スクリーン上のコントラスト比を測定した。なお、投射光学系の集光角は全角で 6度とした。

【０１０５】前記の３種類の混合物から液晶を除いた混合物を作成し、この混合物を紫外線硬化させて、厚さ約 500μｍ、長さ約15mmのフィルムを製造した。このフィルムの20℃と40℃での弾性率を粘弾性測定装置で測定した。

【０１０６】また、主鎖のガラス転移に起因する損失弾性率の極大となる温度を測定した。なお、測定条件は、実施例１と同様にした。また、この素子の電圧－透過率特性におけるヒステリシスの大きさ（ヒステリシスループの面積）も測定した。

【０１０７】これらの結果を表１に示す。画像の切り替え時の焼付き現象については有無、弾性率はN/m^2 で、損失弾性率の極大となる温度は℃で、ヒステリシスの大きさは実施例１のヒステリシスの大きさ（ヒステリシスループの面積）に対する比率で示す。なお、弾性率はいずれも20℃から40℃へ、温度の上昇に対して単調に減少した。

【０１０８】
【表１】

	比較例１	比較例２	実施例２
1)焼付き現象	有	有	無
2)コントラスト比	110	70	80
3)弾性率：20℃	1×10^{8}	4×10^{8}	2×10^{6}
40℃	5×10^{6}	2×10^{7}	4×10^{5}
4)損失弾性率極大温度	11	22	-5
5)ヒステリシス比率	3	10	0.5

【０１０９】
【発明の効果】本発明の投射型液晶表示装置では、用いる液晶表示素子の一対の電極付基板間に挟持される液晶材料として、電気的に散乱状態と透過状態とを制御しうる液晶樹脂複合体を挟持した液晶光学素子を用いているため、偏光板が不要であり、透過時の光の透過率を大幅に向上できる。

【０１１０】本発明の投射型液晶表示装置は、従来のＴＮ型液晶光学素子用の駆動用ＩＣを用いた駆動においても、高コントラスト比を有し、かつ高輝度の表示が可能

になる。

【０１１１】さらに、本発明によれば、階調駆動を行った際にも、中間調がきれいにでた階調表示ができ、ヒステリシスに基づく焼付き現象を低減することができる。このため、本発明の液晶光学素子は、投射型表示に有効であり、画像の焼付きがなく、明るくコントラスト比の良い投射型表示が得られる。また、光源も小型化できる。

【０１１２】また、偏光板を用いなくてもよいため、光学特性の波長依存性が少なく、光源の色補正等がほとんど不要になるという利点も有している。また、ＴＮ型液晶光学素子に必須のラビング等の配向処理やそれに伴う静電気の発生による能動素子の破壊といった問題点も避けられるので、液晶光学素子の製造歩留りを大幅に向上させることができる。

【０１１３】さらに、この液晶樹脂複合体は、硬化後はフィルム状になっているので、基板の加圧による基板間短絡やスペーサーの移動による能動素子の破壊といった問題点も生じにくい。

【０１１４】また、この液晶樹脂複合体は、比抵抗が従来のＴＮモードの場合と同等であり、従来のＤＳモードのように大きな蓄積容量を画素電極毎に設けなくてもよい。このため、能動素子の設計が容易で、有効画素電極面積の割合を大きくしやすく、かつ、液晶光学素子の消費電力を少なく保つことができる。

【０１１５】さらに、ＴＮモードの従来の液晶光学素子の製造工程から、配向膜形成工程を除くだけで製造が可能になるので、生産が容易である。

【０１１６】また、この液晶樹脂複合体を用いた液晶光学素子は、応答時間が短いという特長も有しており、動画の表示も容易なものである。さらに、この液晶光学素子の電気光学特性（電圧－透過率）は、ＴＮモードの液晶光学素子に比して比較的なだらかな特性であるので、階調表示への適用も容易である。

【０１１７】また、本発明の投射型液晶表示装置は、樹脂マトリクスの屈折率と液晶の常光屈折率とがほぼ一致するようにすることが好ましい。これにより、電界を印加しない部分では光が散乱されるため、画素以外の部分を遮光膜により遮光しなくても投射時に光の漏れがなく、隣接画素間の間隙を遮光する必要がない。

【０１１８】このため、特に、能動素子として多結晶シリコンによる能動素子を用いることにより、能動素子部分に遮光膜無しで高輝度の投射用光源を用いることができ、高輝度の投射型液晶表示装置を容易に得ることができる。さらにこの場合には遮光膜を全く設けなくてもよいことになり、さらに生産工程を簡便化することができる。

【０１１９】一般には、液晶固化物複合体を表示素子に用い、さらに投射型表示装置とすることにより高いコントラスト比を得ることができる。何故なら、指向性の高い入射光を利用して、散乱光と直進透過光とを光学系によって分離することができるからである。

【０１２０】しかし、投射型表示装置のライトバルブとして液晶固化物複合体からなる表示素子を用いる場合、入射光はきわめて高密度の光となるために、表示素子内の温度が上昇したり、温度むらが生ずることにより、コントラスト低下や表示面内での表示むらといった表示品位の劣化を起こさせる要因が生じてしまう。

【０１２１】また、投射型表示装置においては、光の散乱と透過性の差がそのまま表示画面上に投影されるために、表示素子の部位での駆動電圧対透過・散乱特性のヒステリシス現象は、表示画面上での焼付き現象を生じさせ、表示品位を著しく損なうこととなってしまう。

【０１２２】本発明による投射型液晶表示装置の構成によって、このような問題点を解決することができる。上述したようにヒステリシスを低減することで、高コントラスト表示における微妙な階調性をも表現することができ、従来にない高輝度でかつ階調性のある高品位の画像を提供することができる。さらに、アクティブマトリクス駆動回路等との組み合わせにより高密度の表示が可能となる。

【０１２３】本発明で用いる液晶固化物複合体での液晶の粒子の大きさの範囲においては、光の制御が透過・散乱型であることによる解像度の低下は問題とならず、極めて良好な高解像度が達成でき、高輝度で高密度の投射型表示が得られる。

【０１２４】本発明は、この外、本発明の効果を損しない範囲内で種々の応用が可能である。

【図面の簡単な説明】

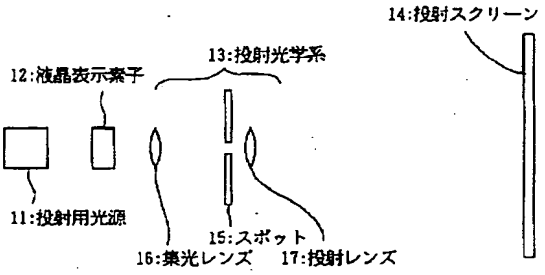
【図１】本発明の投射型アクティブマトリクス液晶表示装置の基本的な構成を示す模式図。

【図２】本発明に用いる液晶光学素子の基本的な構成を示す断面図。

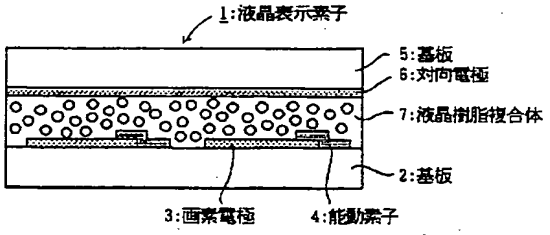
【符号の説明】

１，１２：液晶光学素子
２，５　：基板
３　　：画素電極
４　　：能動素子
６　　：対向電極
７　　：液晶樹脂複合体
１１　　：投射用光源
１３　　：投射光学系
１４　　：投射スクリーン
１５　　：スポット
１６　　：集光レンズ
１７　　：投射レンズ

【図１】



【図２】



フロントページの続き

(72)発明者　郡島　友紀
神奈川県横浜市神奈川区羽沢町1150番地
旭硝子株式会社中央研究所内